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FORD FOUNDATION GRANTS IN ENGINEERING

The Ford Foundation has announced the first major grants in its new program in science and engineering. They total $19,050,000 and will go to ten institutions in the United States. The grants are aimed at the advancement of engineering education. The recipients are:

Massachusetts Institute of Technology	$9,275,000
California Institute of Technology	3,200,000
Carnegie Institute of Technology	2,250,000
University of California (Los Angeles)	1,200,000
University of Michigan	1,175,000
Case Institute of Technology	1,000,000
University of Illinois	275,000
Purdue University	275,000
Stanford University	200,000
University of Wisconsin	200,000

Henry T. Heald, president of the Foundation, announced the program in an address before the annual meeting of the American Institute of Consulting Engineers. "In the last two decades, a revolution has been under way in the practice of engineering," he said. "Yet engineering education—the gateway to professional practice—has lagged behind.

"In a hopeless race against time and reality, most engineering students in their late teens and early twenties are being equipped for the engineering of the last half of the twentieth century by being indoctrinated with the art and practice of the 1950's."

He urged that engineering education impart "a thorough understanding of science and mathematics, their frontiers, and how they may be applied to the needs of mankind."

The Foundation's grants in engineering education, Mr. Heald said, are aimed at two objectives:

—To support promising plans for development of and experimentation with imaginative educational programs.

—To help develop and further excellence on engineering faculties, both by additional training of present faculties and by recruiting and development of increased numbers of well-trained engineering teachers.

Do You Know . . . .

► . . . . That ASEE has received, through the courtesy of the Minnesota Mining and Manufacturing Company, a much needed Thermo-Fax copying machine and a supply of paper? The addition of this equipment will save much office time and facilitate the services rendered to the membership. The generosity of 3M is sincerely appreciated.

► . . . . That the suggestions for officers to be elected for next year resulted in the submission of 93 names for President? Two names were submitted by 18 individuals each, one by 15, one by 12, and one by 10; a total of 22 out of the 93 were mentioned more than once. For Vice President in charge of activities west of the Mississippi River, 99 names were submitted, but 15 had to be eliminated because of their institutions being east of the River. This seems to be a large number of college professors to be confused in geography. For Vice President in charge of instructional divisions and committees, 112 names were submitted, and for Treasurer, 41. Though the large number of suggestions increases the difficulty of the Nominating Committee, the submission of so many names is a healthy indication of the interest of individual members in national officers. The submission of names by new members of the Society was particularly noticeable.

► . . . . That almost every national study of engineering and science education during the post World War period has placed great emphasis on the part to be played by the engineering technician? But much ignorance about the differences between engineering colleges, technical institutes, and trade schools still exists, as evidenced by a survey of groups of high school teachers and guidance counselors, personnel managers in industry, presidents of industrial labor unions, and parents serving as presidents of local PTA's in seven metropolitan areas. The results of this study make good reading. "As Others See Us" by S. C. Marshall is summarized in the Technical Education News, special issue for 1959, published by the McGraw-Hill Book Company.

► . . . . That W. L. Everitt of the University of Illinois has been re-elected President of ECPD for another year? Dr. R. A. Morgen of Rose Polytechnic Institute is the Vice President; F. J. Van Antwerpen, Secretary of the AIChE, is the Secretary; and E. P. Lange, Secretary of EJC, is the Assistant Secretary. F. C. Lindvall of the California Institute of Technology has been re-appointed Chairman of the Education and Accreditation Committee, with N. A. Hall of Yale University as the Assistant Chairman.

► . . . . That the Training Committee of ECPD had a most successful meeting in conjunction with the Annual Meeting in Pittsburgh? The 26 members attending represented all participating societies and all nine sub-committees. One hundred and seven colleges of engineering distributed 26,500 copies of the revised brochure "The First Five Years." The total distribution in the first six months of 1959 was 46,000! The illustrations in the brochure have been redone in multicolor display charts for use at group meetings and two sets of 35 mm. kodachrome slides have been prepared for illustrated discussions by committee members and others. "First Five Years Kits" also have been developed and a plan for the promotion and sale of them is now being developed. Each participating society in ECPD is being asked to appoint a "Committee on Professional Development of Young Engineers" in order to maintain continued activities in the development of the young engineer.

► . . . . That the Education and Accreditation Committee of ECPD last year considered 403 curricula at 87 institutions? Two hundred and eighty curricula at 61 institutions were inspected and 123 curricula from 26 institutions were handled by reports. Based on an inspection requiring four men for four days and the handling of curricula by report as requiring one man for half a day, the time required for the preparation of reports, the committee's time in deliberations, and the preparation of the communications to the institutions, it is estimated that about 1800 man-days per year were required. This is the equivalent of seven to eight men full-time for a year! Still another way of determining the magnitude of this voluntary contribution of time and effort is that if those participating were paid a consulting fee of $100 a day the total cost would be close to $200,000!

► . . . . That a letter from the People-to-People Program indicates that there is a great need in the countries of the Middle-East for engineering publications from the United States. They request that anyone wishing to dispose of text books and technical journals send them to Literature for Engiineers Committee, People-to-People Program, 36–02 Northern Boulevard, Long **Island City,** New York, Attention: Robert B. Lea, Vice Chairman. There is no terminal date for the receipt of the material so it can be sent at any time. It will be necessary for you to pay the shipping charges. The spiritual reward will be great and the material reward, if any, is that such costs are a deductible item in computing federal income tax.

► . . . . That "College Testing" is a new publication of the American Council on Education prepared for the college teacher and administrator who is concerned with testing procedures and materials but who is without formal training in the techniques of testing? The use of measurement devices in institutions of higher learning has increased by leaps and bounds, and expanding enrollments in the 1960's will in all likelihood result in further extension of this practice. All too many professors and administrators possess little or no understanding of tests, their applicability, their range of utility, or their limitations, and this volume is intended to assist teachers and administrators to put tests to use in ways that are appropriate and that contribute to "keeping the individual student at the center of the stage." Testing is not a "cure-all" and those who use the tests should understand what they can and do show and what they can not and do not show. Part I is devoted to the role of measurement in relation to educational problems of the college and Part II to descriptions of seven selected college and university testing programs. Copies may be obtained from ACE at 1785 Massachusetts Avenue, N.W., Washington, D. C. for $3.00 per copy.

► . . . . That the Ford Foundation has awarded a grant of $25,000 to the Pennsylvania State University to support the initial phase of an experimental project designed to provide the foundations for the establishment, at engineering colleges and universities, of in-service programs for the development of young engineering teachers? This initial phase of the project will consist of the planning and preparation of material for the first of a sequence of institutes on the orientation and pedagogic training of young engineering teachers. The awarding of this grant is the direct result of several years of extensive effort and preparation on the part of ASEE. Prominent members of ASEE and ECPD will serve on a special advisory committee to plan the program.

► . . . . That ASEE's participation in the 1960 Nuclear Congress consists of the sponsorship of the Student Day Program? Commander W. R. Anderson will speak on the North Pole voyage of the Nautilus, Dr. N. N. Alyea will speak on Nuclear Energy, the AEC color film on Research Through Controlled Fusion will be shown, and there will be a trip through the exhibits. Dr. H. B. Hansteen represents the Nuclear Committee in developing the program.

► . . . . That Dr. Kenneth G. Picha has been appointed Program Director for Engineering Sciences in the Mathematical, Physical, and Engineering Sciences Division of the National Science Foundation? Dr. Picha has been with the Science Foundation since September of 1958. Prior to that he was Professor of Mechanical Engineering at Georgia Institute of Technology. Dr. N. L. Bennington is Acting Head of the Institute Section, Scientific Personnel and Education. This is the section having responsibility for summer institutes, the NSF program making it possible for teachers to up-grade themselves by summers of study in engineering, science, and mathematics.

► . . . . That "A Study of the Purdue University Engineering Graduate," summarized in the June 1959 JOURNAL, now is available as a bulletin of the Engineering Extension Division of Purdue University? The 295 page bulletin can be purchased for $2.50 from the Dean of Engineering.

► . . . . That "Heat Power News and Views" is a publication of the Mechanical Engineering Division of ASEE? It is published quarterly, in September, December, March, and June, and is available to all interested in the heat-power area. Subscriptions for $1.00 per year should be sent to Professor J. J. Kauzlarich, Mechanical Engineering Department, Worcester Polytechnic Institute, Worcester, Massachusetts.

► . . . . That SCUDS is the featured aspect of the meeting of Section M-Engineering of the AAAS in Chicago on December 28 and 29? The name stands for Simplification, Clarification, Unification, Decimalization, and Standardization of units, and is not a misprint of "suds." The four sessions have as their theme "The Confusion and Chaos In Units;" "Public Education vs the Consumer Public;" "Problems of Design, Manufacture and Commerce;" and "The Look to the Future." The meeting will be at the Morrison Hotel. In addition, on the 29th and 30th Section M joins with others in the sponsorship of a program on "The Great Lakes Basin," the engineering aspects of which will be navigation, power, transportation, water utilization, beach erosion, and water supply. On December 28 there also will be an all-day program on "Higher Education in Emerging Fields of Science and Technology."

► . . . . That the new head of the Graduate Fellowship Program of the National Defense Education Act is Dr. H. E. Bent, Dean of the Graduate Faculty and Professor of Chemistry at the University of Missouri. The program is designed to increase the number of college teachers and to expand and promote wider geographical distribution of graduate school faculties. One of the major reasons why engineering did not fare better than it did last year was because the applications did not indicate a possible interest in engineering teaching. The applicant need not make a promise, but he should mention engineering teaching as a possibility. Fifteen hundred fellowships are provided for 1960–61 and for the two succeeding years. Congress has been asked to appropriate $13,450,000 to continue the 1,000 fellowships granted last year into their second year and to establish 1,500 new ones.

► . . . . That a two-day conference is being held at Worcester Polytechnic Institute on December 3 and 4 to discuss the development of better means of communication of ideas in research? The objective is to stimulate young research scientists and engineers to undertake projects which have great promise of significant discovery. ASEE is one of 15 scientific and engineering societies cooperating in the NSF-financed conference. It is hoped that ways and means can be discovered for the development of new centers of research and their rapid development, and by which scientific and engineering societies as well as colleges and universities can influence discovery and accelerate the application of new science to new technologies.

W. LEIGHTON COLLINS
Secretary

OFFICERS NOMINATED FOR 1960-61

The Nominating Committee met in St. Louis, Mo. on Thursday, November 12 and selected the following candidates:

For **President,** one year.....Eric A. Walker

President, The Pennsylvania State University; member of General Council, 1950–52; Vice President, 1952–54; Chairman, ECRC Advisory Committee, Research Capabilities and Potentialities; member, Committee on Evaluation of Engineering Education; member of ASEE since 1938.

For **Vice President,** General and Regional Activities West of Mississippi River, two years.....Melvin R. Lohmann

Dean of Engineering, Oklahoma State University; member of General Council, 1954–56; member of ASEE since 1946.

For **Vice President,** Instructional Division and Committee Activities, two years.....Newman A. Hall

Professor and Chairman of Mechanical Engineering, Yale University. Chairman, Graduate Studies Division; Chairman, Mechanical Engineering Division; Chairman, Graduate Study Commission; member of ASEE since 1948.

For **Treasurer,** one year.....Wendel W. Burton

Employment Manager, Minnesota Mining and Manufacturing Co. Treasurer, 1959–60; Chairman, Ethics Committee, 1957–59; member of ASEE since 1947.

ADDITIONAL NOMINATIONS

In accordance with the revisions of the constitution and by-laws adopted in June of 1957, *additional nominations may be made by petition* of fifty (50) signatures of members of the Society in good standing. The nominee must indicate a willingness to serve, if elected, before his name can be placed on the ballot. Petitions are to be submitted to the Secretary of the Society by January 15, 1960.

In the February 15 issue of the JOURNAL OF ENGINEERING EDUCATION ballots giving the names of all candidates will be provided. Ballots received by the Secretary by March 31 shall determine the election of the officers as of April 1. Their terms of office shall begin ten days after the date of the annual meeting.

Engineering Science and the National Science Foundation

A Report to the American Society for Engineering Education

GORDON B. CARSON
CARL C. CHAMBERS
GENE M. NORDBY
RALPH A. MORGEN
ROBERT H. ROY, *Chairman*

Throughout engineering schools and colleges the opinion has persisted that the National Science Foundation has been prejudiced against engineering in awarding funds for research grants, fellowships, and summer institutes and conferences. Because of the prevalence of this belief, and in the hope of improving the position of engineering sciences, President Alexander appointed the following ad hoc committee to improve liaison between ASEE and NSF:

Gordon B. Carson, Vice-President, The Ohio State University,

Carl C. Chambers, Vice-President, University of Pennsylvania,

Ralph A. Morgen, Director, Purdue Research Foundation,

Gene M. Nordby, Professor and Head, Department of Civil Engineering, University of Arizona,

Robert H. Roy, Dean, School of Engineering, The Johns Hopkins University, Chairman.

This report consists of five parts. The first discusses the organization and purposes of NSF and their relevance to the engineering sciences. The second deals with research grants, and the third with research proposals, how they should be prepared and how they are evaluated and awarded or rejected. Fellowships constitute the fourth section, and the final portion deals with NSF support for summer institutes and conferences. The objective is to present constructive suggestions and direction to the Society, rather than merely to voice criticism of the Foundation.

Organization and Purpose

The National Science Foundation functions under a National Science Board responsible for general direction and policy within the framework of governing legislation. Eight members of the Board retire each two years and are replaced by new appointees. Engineering representation on the Board appears adequate.

Dr. Alan T. Waterman is Director of the Foundation. He is assisted by two Associate Directors, Dr. Robert B. Brode and Mr. James M. Mitchell, and by Assistant Directors in charge of various divisions and activities of the Foundation. Dr. Randal M. Robertson, Assistant Director for Mathematical, Physical, and Engineering Sciences (referred to as the MPE Division), and Dr. Harry C. Kelly, Assistant Director for Scientific Personnel and Education, are in positions of importance to the engineering sciences, Dr. Robertson with respect to research grants, Dr. Kelly for fellowship and institute and conference support.

Within the MPE Division there are seven programs, each headed by a program Director. At the present time Dr. Arthur Waynick, on leave until September 1959 from his position as Professor and Chairman of Electrical Engineering and Director of the Ionosphere Research Laboratory at Pennsylvania State University, is Program Director for the Engineering Sciences. Dr. Waynick is at present assisted by Drs. Picha, Reeds, and Kobayashi, all of whom are on leave

from the faculties of engineering institutions.*

Two members of this committee, Drs. Morgen and Nordby, have formerly served as Program Directors for Engineering Science. The fact that the Program has been presided over by five different directors over a short span of years, with a sixth soon to be named, is a matter of consequence. Some programs within the MPE Division have had continuing direction during this same period.

NSF organization also provides Advisory Panels for each Program and there is one for Engineering Science, presently under the Chairmanship of Dr. Paul Chenea. There is also an Advisory Panel for the MPE Division, presently under the Chairmanship of Dr. F. E. Terman. Three of the twelve members of this divisional committee have engineering backgrounds.

Of those NSF executives named, it is important to observe that nearly all in positions of importance to engineering hold degrees in physics. Dr. Waterman is a physicist and so also are Drs. Brode and Robertson. Dr. Waynick, now in electrical engineering, first served as a teacher in physics.

This seeming dominance of the NSF organization by physicists is important because it has helped to create the widespread belief that the physics point of view has been given precedence to the detriment of the engineering sciences. The committee also has entertained this suspicion, and has looked for evidence to support it. Although there is some reason to believe that engineering has been frowned upon in the past, we have found no evidence of bias against engineering today, nor of bias for or against any other program.

Corollary to this belief is the widespread notion that engineering science is short-changed for another reason. Legislation creating the NSF required that it restrict its support to *basic* science and there are those who hold that support for engineering is curtailed because of the inaccurate and inimical belief that engineering by definition must be applied and not basic. Again, influenced by past experience and belief, the committee has looked for evidence of discrimination against engineering and, with appreciation of the fact that NSF supports *engineering science* but not *engineering practice*, has found none. On the contrary, we have come to the opinion, necessarily on subjective grounds, that the affairs of NSF at present are wisely and fairly administered.

* Since this writing, Dr. Picha has succeeded Dr. Waynick as Program Director for the Engineering Sciences.

Research Grants

Budget procedures for the National Science Foundation are similar to those for other organizations in the Federal Government, with proposal, evaluation, and appropriation by the Congress in the usual way. Of more direct concern to the committee has been the allocation of funds for the support of research in the engineering sciences. Total NSF funds allocated to research are first divided among the Biological and Medical Sciences; the Mathematical, Physical, and Engineering Sciences; and the Social Sciences. In fiscal 1958 research grants for these were respectively 8.88, 9.51, and 0.73 millions.

These divisional allocations are then sub-divided by forecasts of allocations to the programs which comprise each division. Dr. Robertson, as Assistant Director of NSF in charge of the MPE Division, has stated that this decision is the most important one he is called upon to make. In fiscal 1958 the 9.51 million in research to the MPE Divison was subdivided as follows:

Astronomy	$1.02 million	33 grants
Chemistry	2.32 million	134 grants
Earth Sciences	1.25 million	70 grants
Engineering Sciences	1.54 million	88 grants
Mathematics	1.24 million	72 grants
Physics	2.14 million	69 grants
	$9.51 million	466 grants

This is a record of grants made, not an allocation forecast. However, forecasts would show comparable data.

The important thing to engineering is

the decision to allocate approximately $1.5 million to the engineering sciences out of the $9.5 million available to the Division. It is also important to realize that both Division and Program funds, however apportioned, are inadequate to meet the applications received. The problem thus is one of allocation of scarce—in this case *very* scarce—resources. There simply is not enough to go around, a circumstance which is conducive to dissatisfaction to applicants whose worthy proposals are necessarily rejected.

NSF policy is to support about 40% of the meritorious proposals received (those judged meritorious amount to about 80% of all proposals submitted) but available funds reduce this goal to about 25%.

The decision as to how Division funds are to be apportioned to the several programs for a coming fiscal year is based upon two principal considerations: (1) the number of meritorious proposals received in each program during the preceding year, and (2) the relative excellence of these proposals. Meritorious proposals are those judged excellent, very good, or good by the referees in the manner described below.

Members of the committee have been shown quantitative data on the first of the two points given above, with the understanding that the figures themselves would not be disclosed. These data quite clearly show that a smaller proportion of meritorious engineering science proposals receive support than those for *any other* program within the MPE Division. Over a several-year span the ratio of grants made to meritorious proposals received was lowest for engineering, except for one year, when engineering ranked next to last.

This revelation was first received by the committee as confirmation of the prevailing point of view, that engineering is indeed the victim of discrimination. However, with respect to current operations, examination of the second consideration has changed this opinion.

Within the meritorious categories, good, very good, and excellent, ranking is done and apportionment of Division funds is then made to yield approximately the same cut-off point in order of excellence for each program. During the spring, when proposals are most numerous, NSF will be more selective than at other times but in general the cut-off point is the G + range. Engineering Science has proportionately fewer meritorious proposals at and above that level than are received by the other Programs. We do not have quantitative data on this important statement but believe it to be correct. Corroboration has been given by members of the committee who are in a position to know and by former members of the Advisory Panel for Engineering Sciences.

This, however, does not necessarily mean that engineering science proposals are less meritorious than those submitted to the other programs. It is possible that engineering science referees are more severe in their judgements than mathematicians, physicists, or chemists. Mathematics, for example, has often had 50% of its proposals rated excellent; at the very least this is an indication of a skewed distribution, in contrast to the more normal pattern of engineering science evaluations. This suggests that engineers are perhaps hard upon themselves, a condition which this committee can point out but not correct.

In summary, we believe that engineering is not a victim of discrimination by NSF, although this may have been so in the past. We have found no evidence that support for engineering science is constrained by the "physics point of view" or by the notion that engineering science is by definition "applied" and therefore not "basic." On the contrary, such insight as we have has been gained by the forthrightness and candor with which we have been received, and the complete access we have been given to the information sought. If our conclusion is correct, and we believe it is, then a strategy of improvement rather than complaint is the best remedy for the relatively poor position of engineering. The following section will be directed to that strategy.

Research Proposals

Members of this committee have been permitted to examine a representative array of research proposals, with the understanding that confidence will be maintained. Out of this experience some constructive suggestions may be given. It is not our purpose to give routine instructions for submission of research proposals; these can be obtained in pamphlet form by request to NSF.

Basic vs. Applied Research

Mention already has been made of the fact that governing legislation requires NSF to support *basic* research. This means, conversely, that NSF may *not* support applied research or technological development per se. No adequate definition can be given of either term. Basic research may result in application and applied research can at once be both applied and basic. Nor can a line of demarcation be drawn to distinguish where one shades into the other. Nevertheless, there are clearly identifiable extremes and the requirement that a proposed investigation be fundamental, broad, and basic, rather than pragmatic, narrow, and applied, is of first importance among criteria for approval.

Exemplification of this point is difficult. In general, NSF will not grant support for investigations which merely involve data taking or routine testing. Thus, a proposal (the example is fictitious) to investigate the dielectric properties of proprietary plastics under varying conditions of electric stress, temperature, humidity, etc., would be rejected, not because the resulting tables of design data would be unimportant, but because the research would be deemed routine, rather than basic.

In like manner, a proposal to measure the heat transfer properties of one or two specific materials probably would be rejected. To win support it would be necessary to broaden the scope of the proposal to encompass research on the mechanism of heat transfer in a class of materials, in which those specified might serve as examples.

NSF will not grant support for research concerned solely or even principally with the construction of a device, particularly if the device envisioned would be of limited scientific utility. On the other hand, a device of potentially broad usefulness, as for example an ultra high pressure instrument, or a basic research proposal in which the creation of a device is an important part, might win approval.

Proposals for investigations of very specific things for very specific purposes are not likely to be supported either, nor are fields which already have been intensively explored. For example, proposed fatigue studies of a particular alloy at high or low temperatures would be considered applied research and would not be supported, particularly in the light of the extensive research already done in the field of metals. But fundamental studies on dislocation or on the behavior of individual crystals might well win support. And so also might statistical studies on fatigue in concrete, since this field has been less thoroughly explored than fatigue in metals.

Referees

Research proposals submitted to NSF are initially screened by the Program Director and his staff. Only those of obviously poor quality are rejected at this stage because the spectrum of proposals is so broad that no small staff could be capable of fair evaluation. On this account, all proposals for which support is deemed possible are submitted to referees.

At the present time NSF lists and draws upon the voluntary services of some 800 engineering scientists and it is they who, by their ratings, chiefly determine whether a proposal will be supported or rejected. If the referees rate a proposal excellent or very good, it will be approved; if they rate it fair or poor, it will be disapproved. If a proposal is rated variously, or if it is rated at or near the cut-off point, additional opinions will be sought. In all cases, of course, the final decision is made by staff of the Program and Division but the opinions of referees are the chief determinant. Referees' ratings, it may be added, are remarkably consistent, seldom going more

than one grade above or below the consensus.

Evaluation by referees who are in a very real sense co-workers is important in another sense. The language of any proposal is important to its acceptance or rejection, and research proposals can succeed best if written as though addressed to peers and colleagues. The language of proposals need not make the subjects clear to a tyro or even to an engineering scientist in some other field. This does not mean that clarity is not a virtue; it simply means that writing should be directed to those in the field of the investigator himself. He need not and should not "write down" to his audience, nor should he make his proposal abstruse merely to appear erudite.

Screening

A corollary point may be added to this admonition on preparation. Institutional screening by colleagues at home is highly desirable. Adoption of such a practice at one university has resulted in a high percentage of successful NSF proposals.

Professional Competence

Among the determinants important to acceptance or rejection of a research proposal is the professional competence of the investigator and this should be stated optimally in the proposal. Directions for "optimal" presentation obviously are impossible to give; one can only emphasize the importance of the point and suggest that the author neither gild the lily on the one hand nor assume that he is widely known on the other.

The fact that professional competence is a requirement, however, should in no sense discourage young investigators from submitting research proposals. The Foundation will often favor proposals from young research workers, who have not yet established reputations, as part of its mission to encourage American science.

Institutional Support

Evidence of support from the institution in which the investigator holds appointment is also of importance. This does not mean that the college or university must pledge its funds or underwrite the project, but it does mean something more than institutional apathy for research.

Again, however, there is a policy of encouragement to investigators in institutions which do not have a research tradition but where there is sincere desire on the part of administration to develop a sound research effort.

Budget

Budgets for research proposals require wisdom, restraint, and objectivity, an obvious but important thing to say. Inflated, self-seeking demands or cushioned requests in anticipation of cuts are very likely to jeopardize the entire proposal and may lead to out-right rejection. It should be borne in mind that available resources fall far short of total demand; reasons for the support of *this* proposal as opposed to other demands for research should be emphasized.

Foundation grants for research are made for periods of from one to five years, with two to two and one-half years about the present average. About 30% of the grants in engineering science are continued by additional awards; these are subjected to the same evaluation procedures as are applied to original proposals.

Growth in Engineering Science Research

As is well known, the scope of graduate study in engineering is growing at a rate exceeding that in other disciplines. This is reflected by a steep rise in the number of engineering science proposals and it may be expected that this will continue in the near future.

Engineering science research proposals to NSF thus may expect to fare relatively better in the future, not only because available funds are being increased but also because of improvement in the quality and quantity of proposals. This will happen with or without this report but obedience to the precepts set forth above can help to hasten the process.

Fellowships

In fiscal 1958 the National Science Foundation offered a total of 1,527 fellowships worth approximately $5.6 million. These were distributed as follows:

Field	Predoctoral			Post-doctoral (regular)	Senior post-doctoral	Science faculty	Total
	First year	Inter-mediate	Terminal year				
Life sciences	65	122	63	59	32	67	408
Chemistry	76	95	53	33	12	37	306
Engineering	71	49	27	2	3	41	193
Earth sciences	18	26	14	2	4	9	73
Mathematical sciences	58	60	22	19	11	36	206
Physics and astronomy	98	111	40	33	11	21	314
Physical sciences general	0	0	0	0	0	1	1
Natural sciences general	0	0	0	0	0	4	4
Convergent fields	3	8	5	3	3	0	22
Total	389	471	224	151	76	216	1,527

Of the four kinds of fellowships tabulated, all are of importance to engineering but the predoctorals are of principal interest here. Engineering candidates received 147 out of the total of 1,084 awards made. For the academic year 1959–60 a total of 1,100 Graduate Fellowships have been awarded and 1,979 persons accorded Honorable Mention out of a total of 4,506 applicants.

To compare the success of engineering applicants with those from other sciences, an attempt has been made to secure the following information:

a. The total number of awards for each year of the fellowship program.
b. The total number of applicants.
c. The number of awards to engineering.
d. The number of engineering applicants.

These data are presented by Dr. Thomas Fontaine of NSF (p. 216).

All of the foregoing applies to NSF Graduate Fellowships which permit recipients to select the institutions of their choice for advanced study. As might be expected, this has resulted in considerable concentration in a relatively small number of institutions, indicated by the following partial rank order:

Harvard	129
MIT	84
University of California	68
California Tech	65
Princeton	52
Chicago	50
Wisconsin	47
Stanford	45
Yale	31
Columbia	30
Illinois	29
Michigan	28
Total	658

Thus, well over one-half of all NSF graduate fellows elected to study in only 12 of the 83 institutions listed. Again, details for engineering are not available.

Largely because of this concentration, NSF has introduced the Cooperative Graduate Fellowship program, beginning with approximately 1,000 awards in 1959–60. Nominations for these awards are made on behalf of applicants by the institutions themselves and it is anticipated that this will result in greater dispersion and broader encouragement to graduate study and research throughout the country.

In the absence of more detailed information, this committee can only recommend that engineering institutions give their superior students every encouragement to apply under the NSF fellowship program.

Summer Institutes

During fiscal 1958, NSF supported three kinds of institutes "designed to improve the subject-matter competence of high school and college teachers of science and mathematics" (1958 Report, p. 54). Two of these, the Academic-Year Institutes and the In-Service Institutes, are for high school teachers only and are not of interest here. Of the 126 summer institutes held in 1958, five were for college teachers only and three were for both high school and college teachers; the remaining 118 were only for high school teachers.

Despite this seeming paucity of support for college level institutes, engineering schools and colleges should be encouraged to consider such programs because of their intrinsic merit and because support for summer institutes for college teachers will be expanded in 1959 and presumably thereafter as well.

As in the case of research grants, directions for the preparation of summer institute proposals may be had by application to NSF. The suggestions already given in this report for the preparation of research grant proposals are to a considerable extent germane here, with perhaps some differences in flavor:

a. The proposed institute should be well thought out and programmed in reasonable detail, not merely stated as an "institute for college teachers in mechanics," or a "four week institute on computer programming." It is not wise to assume that the evaluators will approve a program on faith.

It is essential to note that NSF will support institutes designed to improve "subject-matter competence" and this means that support will *not* be given to institutes devoted to pedagogical methods, purporting to improve the quality of teaching.

b. Staff for the proposed institute should be competent, of course, but something more is necessary. It is not sufficient to say that "such persons as Dr. Doe and Professor Roe *will* be invited to lecture, *if* the institute is supported." Support is much more likely to be given if suitable staff have accepted such invitations when the proposal is made.

c. Budgets, as always, should be prepared as realistically as possible. NSF support for summer institutes covers participants as well as the sponsoring institution and staff but this broad coverage is subject to usual and proper restraints. Submission of an inflated budget may result in deflation—but it may also result in denial.

d. Evidence of administration interest is also of importance. An enthusiastic faculty sponsor will have a much better chance of gaining support for his proposal if he can reveal comparable enthusiasm and approval from his dean, provost, or president as well.

These admonitions have come from experience in the evaluation of proposals for the summer of 1959. Each year NSF brings together representatives from various fields of science (there were three from engineering out of a total of about 20) and each evaluator reads and independently grades each proposal submitted. These are then correlated by two groups, each comprising about half of the number of evaluators, and then a final meeting of the entire group serves to achieve a consensus. The uniformity of opinion on most of the proposals is quite striking, and discussion resolves such differences as may appear. Thus, in framing proposals for summer institutes, faculty may proceed with the knowledge that their requests will be evaluated by a jury of their peers, rather than by NSF staff alone.

Recommendations

1. From time to time, during the many contacts with NSF made by members of this committee, it has been pointed out that the interests of engineering may be impaired by the presence of too many spokesmen. Members of the staff at NSF and members of the Advisory Panel as well have been importuned by NSPE, by EJC, by the Land Grant College Association, by various professional societies in engineering, by ASEE, by individuals

acting officially on behalf of these organizations, and by individuals acting unofficially as well.

With the possible exception of the Land Grant College Association, no other organization has as direct an interest in the affairs of NSF as ASEE. Despite this, because of the evident desirability of having engineering speak with one strong voice rather than with a babble of small voices, we recommend that liaison between engineering and the National Science Foundation be centered in EJC, the single engineering organization for which such a unifying mission is appropriate. To make such a recommendation effective it would be essential that ASEE be strongly represented at all times by members proposed to EJC by the Society itself, but there is no reason why that cannot be accomplished within the framework of EJC. It would also be necessary, of course, for other engineering organizations to conform by relying upon EJC, rather than by speaking for themselves.

2. If this recommendation is accepted and carried out, we further recommend that NSF be informed that EJC is the focus of liaison between them and engineering and, correspondingly, that others, both official and unofficial, are not.

3. We recommend that maximum assistance be given to NSF—again preferably through a suitable EJC committee—in seeking staff for the Engineering Science Program. The return of Dr. Waynick to his post at Pennsylvania State in September 1959 will deprive the Program of a capable leader and it is essential that a competent replacement be found. As pointed out previously, other programs are presided over by more permanent "career" men, while engineering directors have rotated each year or two. Permanent appointment of a capable director to the Engineering Science Program is highly desirable.

4. We recommend that consideration be given to proposing to NSF the formation of a Division of Engineering Science, ultimately to become co-equal with the present MPE and Biological Science Divisions. We do not make this recommendation because of any belief that engineering has been or will be persecuted but for other, more objective reasons. Engineering science is not one program but many, embracing as many branches in itself as all of the other programs in the MPE Division. Furthermore, there are many signs that engineering science is likely to become essentially a graduate discipline in the years to come; whether this happens or not, the growth rate in both graduate study and research in engineering will exceed that of the other sciences, a trend that is already apparent. These facts support our belief that greater autonomy for engineering will be in the national interest.

5. We recommend to NSF that an inter-program evaluation of referees' ratings be made for the purpose of determining relative severity or leniency in assigning grades to research proposals. Evidence suggests that there exist significant differences between programs; this may be due to real differences in the quality of proposals, but it may also mean differences in judgment. Should this latter possibility prove to be the case, corrective steps to preserve equity should be taken.

• • •

If our first recommendation with respect to EJC is carried out, this committee will have served its immediate purpose and may be discharged. Until then, subject to your wishes and those of your successor, we are willingly at your service.

Support of Basic Research by the Engineering Sciences Program of the National Science Foundation

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In connection with the interest expressed by the ASEE Committee on Relations with the National Science Foundation, the Engineering Sciences Program staff initiated a careful study of its activities in the support of basic research in the engineering sciences over the past several years. The purpose of the present discussion is to present in some detail the results of this study which may indicate the manner in which the program is administered, and several interesting results of the study concerning the basic research grants made to the nation's engineering schools. The role of the Engineering Sciences Program of the National Science Foundation in the support of basic research in the engineering sciences has been fully explained in papers by Faiman, Nordby, and others (1).

Processes which a proposal for the support of an engineering research investigation undergoes upon submission to the National Science Foundation are illustrated in Figure 1. As indicated, the research idea originates with a staff member at a particular institution, and the resulting proposal is handled through the institutional administration before it enters the National Science Foundation. The proposal is then forwarded to the Engineering Sciences Program by the administrative staff of the Office of the Assistant Director for Mathematical, Physical and Engineering Sciences. Based on the recommendation resulting from the Engineering Sciences Program staff study, the request for the support of research is either granted or declined as indicated in Figure 1. In some cases, however, the proposer will be advised as to other support sources which might provide suitable support for the research proposed or the proposer may be advised to withdraw the proposal, revise it, and resubmit it. After proper administrative analysis, the request for a grant may be approved by the National Science Board, a group appointed by the President of the United States, and the grant is made directly to the institution from which the proposal had originated. As a matter of general interest, other offices and divisions, as well as other programs of the Mathematical, Physical and Engineering Sciences Division, also appear on the flow diagram.

The actual procedures followed in the treatment of proposals within the Engineering Sciences Program are indicated in Figure 2. Preliminary reviews of the proposal are provided by the staff specialists to determine whether it fits in the category of research which the National Science Foundation supports, also to determine the scientific merit of the proposal, and further to assist the proposer when necessary in establishing as strong a request for support as possible. Upon completion of the preliminary review by the staff, competent colleagues are selected from various sources to serve as reviewers. Typical sources of reviewers are indicated on Figure 2. These outstanding specialists in the field of the proposed investigation are the main core of the reviewer process, and the indebtedness of the engineering profession to these individuals for their voluntary services is most gratefully acknowledged. Continuity in the review process and uniform treatment among the various engi-

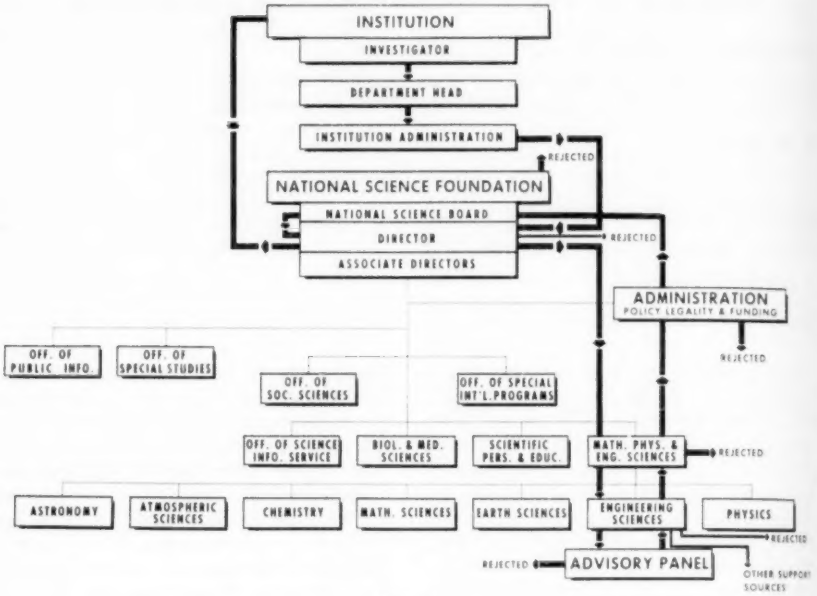

FIG. 1.

neering disciplines for each proposal entering the program are assured by reviews from the Engineering Sciences Program Advisory Panel by virtue of their three-year appointment. After the review process has been completed, the staff evaluates the reviews and where necessary will request a rebuttal from the

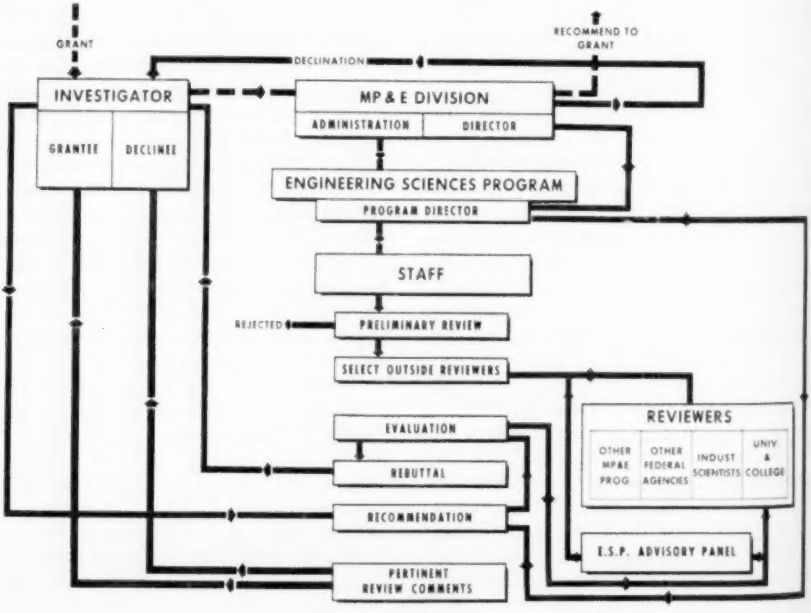

FIG. 2.

proposer of critical review comments. On completion of the evaluation, a recommendation is made by the Program Director to either support or decline the request. The recommendation is then forwarded to the administration of the National Science Foundation for final action. After the proposer has been notified as to either a grant or declination, review comments may be extracted and sent to the proposer. In case of a declination these comments are to assist the proposer in revising the declined proposal or in the preparation of a new proposal. In the case of a grant the comments may be of possible value in the initiation or conduct of the research. In view of the outstanding ability of the reviewers selected, these review comments have been found to be of inestimable value.

Table II of the paper by Faiman and Nordby, referenced above, presents the proposal receipts and grants in the Engineering Sciences Program of the National Science Foundation for the Fiscal Years 1952 through 1958, inclusive. The following data will bring this table up to date. The number of research proposals received in 1959 in the Engineering Sciences Program was 309 and the dollar value of these proposals was $13,449,000; 129 research grants were made during 1959 for a total of 4.3 million dollars.

Processing Time

To provide some idea as to the time required for processing proposals in the Engineering Sciences Program, the grants made during the year 1958 were studied to determine the time required to decline a proposal after submission and, secondly, to determine the time required to provide a grant to the principal investigator. The data presented in Figure 3 are for only Fiscal Year 1958 and, in fact, represent only 79 research grants. The number of months required for the approval or declination of proposals received during various quarters of the year is indicated in the upper histogram. The difference between the time required for the approval of a proposal and the length of time required for a declination can be explained by the additional administrative processing required in the case of the former as indicated in Figure 1.

The lower histogram on Figure 3 shows the percentage of total approvals

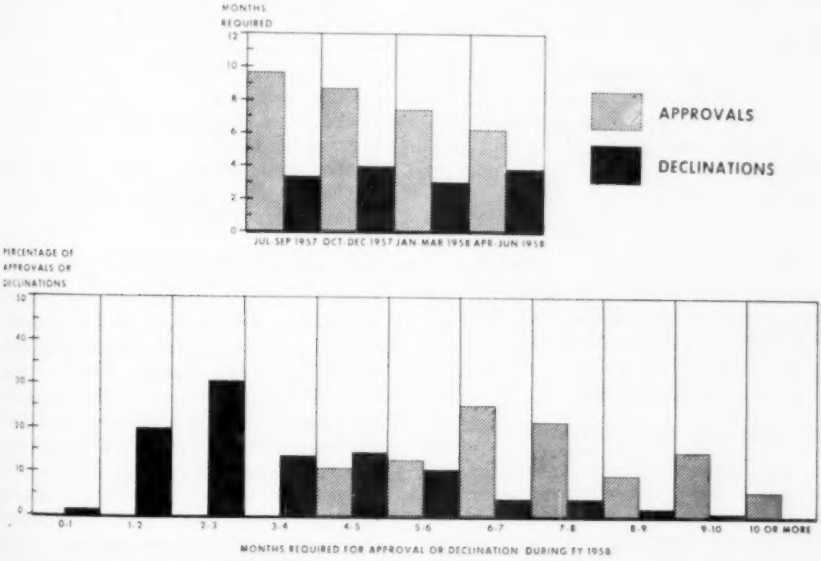

FIG. 3.

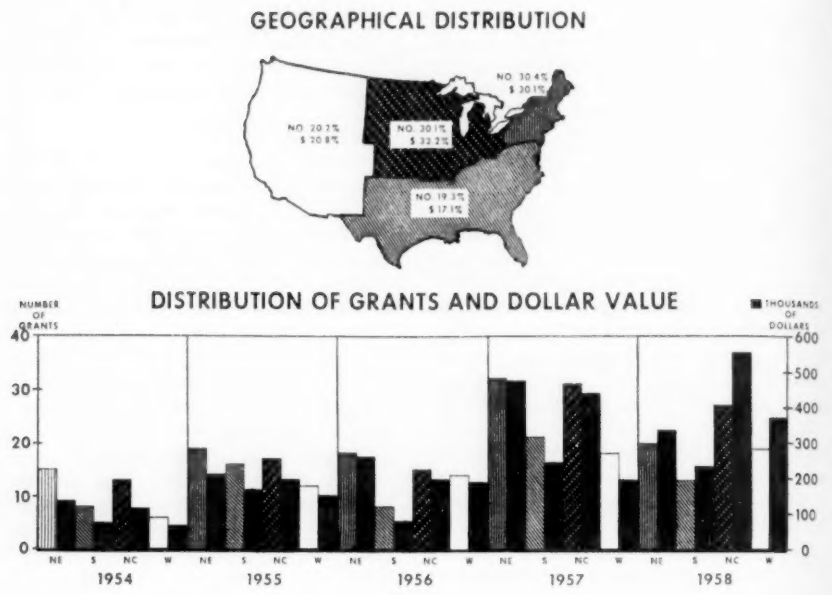

FIG. 4.

or declinations which required from 1 to 10 months for final action during the Fiscal Year 1958. The average processing time has been reduced from 6.9 months in Fiscal Year 1954 to 4.42 months in 1958.

As a matter of interest the staff examined 123 randomly selected grants where the age of the principal investigator could be established. Over one quarter of the grants studied were made to principal investigators in the 26- to 35-year age bracket. Secondly, roughly one third of the grants were made to investigators in the 36- to 45-year age bracket. An equal percentage of the grants were made to investigators in the range 46 to 55, and a small portion of the grants were made to investigators in the 56 and over age bracket.

Geographical Distribution

The National Science Foundation attempts to provide support to universities in the various geographical areas of the nation, and steps are taken to avoid an undue concentration of funds in certain sections. The data in Figure 4 were assembled to indicate the geographical distribution of engineering sciences grants during the past five years. The upper diagram divides the nation into four sections, the Southeast, the West, the North Central and the Northeast. Both the percentage of engineering grants by number as well as the percentage of grant funds made during the last five years to universities in the various sections of the nation are indicated on the upper diagram. In the lower histogram of Figure 4, both the number of grants and the total value of the grants given to each of the four sections for the years from 1954 to 1958, inclusive, are presented.

Schools and Departments

As a first step in establishing a rough estimate of the level of graduate education of the institutions receiving Engineering Sciences support, Table 1 was prepared to show the number of grants which were made during the period 1956 through 1958, inclusive, to engineering departments granting PhD degrees. As a matter of interest, the largest number of engineering grants went to chemical engineers, while the electrical, metallurgical and aeronautical engineers received relatively few engineering grants. Perhaps this is best explained by realizing that very little other Federal support exists for some disciplines, such as chem-

TABLE 1

DISTRIBUTION OF GRANTS FY 1956–1958 TO PH.D. GRANTING DEPTS. IN ENGINEERING

Departments	Ph.D. Prog.	No Ph.D. Prog.
Chemical	50	16
Civil	24	11
Mechanical	26	5
Electrical	24	4
Metallurgical	19	4
Engineering mechanics	10	3
General engineering	5	8
Others:		
Aeronautical, Architectural, Agricultural, Ceramic, Engineering physics, Mining, Unclassified	9	14
Totals	167	65

ical engineering, whereas other disciplines, such as electrical engineering, receive support from many Federal agencies.

A recent study by the Survey Committee of the Engineering College Research Council of the ASEE published by the ASEE in 1958 (2), made the following classification of the research interests of the engineering administrators of colleges and universities in the nation:

A. The administration expects staff to contribute research.
B. Administration gives active support to research.
C. Administration gives moderate support to research.
D. Administration gives passive support to research.

The number of grants made by the Engineering Sciences Program for the years 1954 to 1958, inclusive, to universities in each of the ECRC categories is presented on the left-hand side of Figure 5. The right hand side of Figure 5 presents the total number of grants as well as the percentages for the period under consideration. These data indicate that by far the majority of the Enginering Sciences Program grants went to universities which provided active support to research. A similar situation exists in terms of the number of dollars granted to schools of classifications A, B, C and D. Over 85% of the engineering sciences funds granted during the period 1954 through 1958 went to the universities and colleges which gave strong support to research.

Use of Funds

One of the most important functions of the NSF grants in the Engineering Sciences is the support of predoctoral graduate students working as research assistants. Information relative to the number of dollars and the number of man years supported by the Engineering Sciences Program during the years 1954 to 1958 is presented in Table 2. The number of predoctoral graduate student man years supported for each year was obtained by taking the product of the number of research assistants requested and the duration of the grant. Since some of the graduate research assistants supported in the proposals granted in any one year may have received support for more than one year, the total number of predoctoral students supported by the Engineering Sciences Program of National Science Foundation in any succeeding year may be larger than the number shown. The number of man years supported has more than doubled during the last five years as well as the total funds for this purpose. As a matter of interest, the almost linear increase in the number of dollars per man year of support presented in the last column of Table 2 indicates the increasing costs of supporting graduate students.

The percentage of total research funds granted by the Engineering Sciences Program during the period 1954 to 1958 in the support of the principal investigator, the research associate (usually a post

TABLE 2

GRANT FUNDS TO SUPPORT PREDOCTORAL RESEARCH ASSISTANTS

FY	Man Years	Dollars	% of Grant	$/Man Year
1954	78.5	139,770	35.8	1781
1955	124.0	244,058	33.7	1970
1956	117.0	254,659	35.1	2175
1957	185.0	422,578	36.7	2285
1958	196.0	468,541	31.4	2390

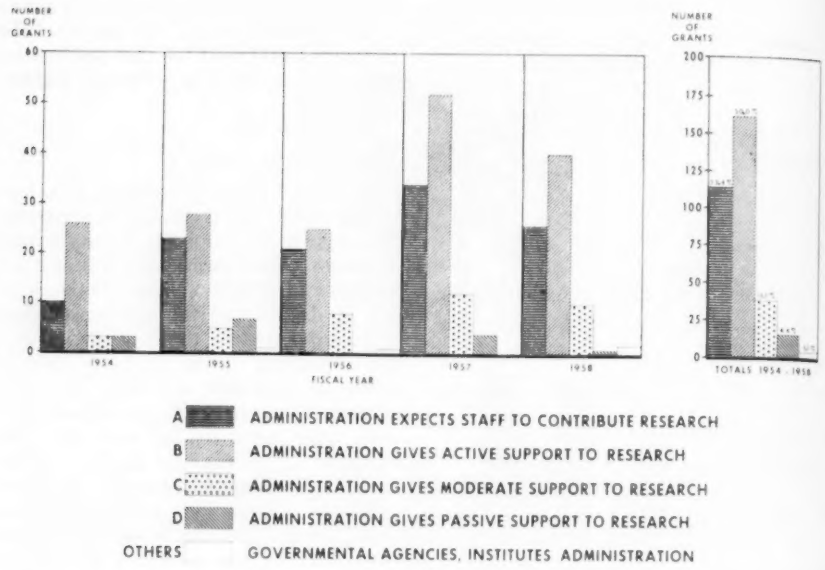

FIG. 5.

doctoral fellow), the research assistant, and finally the undergraduate assistant is shown on Figure 6. By far the largest portion of grant salary funds are in the support of the graduate research assistant, about 35% of the total grant funds.

Further breakdown of the remaining portion of funds granted during the pe-

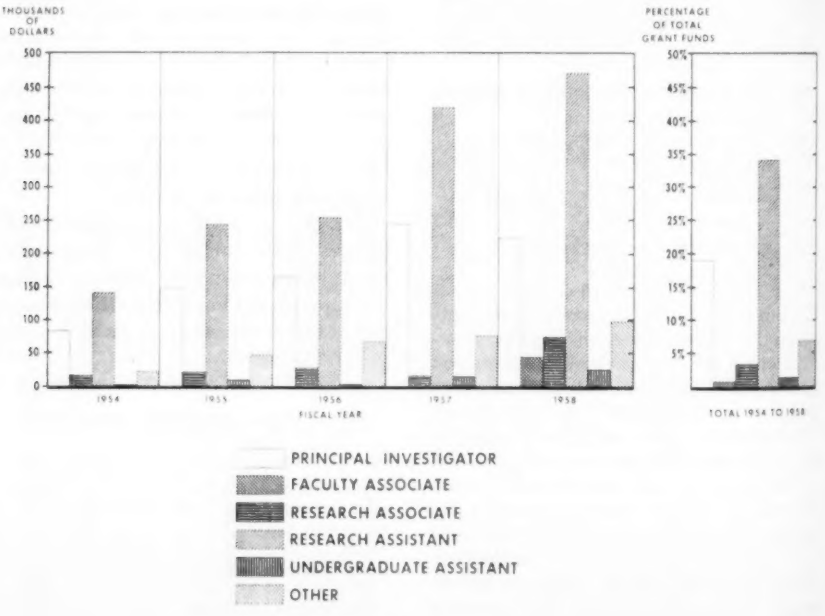

FIG. 6.

riod 1954 to 1958 is shown on Figure 7. Clearly the most significant portion of the Engineering Sciences Program grants goes into the support of the graduate student and the procurement of permanent equipment so vitally needed to carry out engineering research.

Average grant size data for the past five-year period are presented in Figure 8. The broken line in the upper portion of Figure 8 demonstrates that the Engineering Sciences Program average grant size is running fairly close to the average grant size for the Mathematical, Physical and Engineering Sciences Division. The lower histogram of Figure 8 shows that until 1958 very few grants exceeded $25,000; however, since that time the number of larger grants has increased significantly, reflecting the larger amounts of money made available for the Engineering Sciences Program to support the nation's engineering educators and researchers. Similar information for the average grant duration is presented on Figure 9. Again the Engineering Sciences Program average grant duration runs reasonably close to the average grant duration of the division. The lower histogram in Figure 9 shows that, although the majority of grants are for a period of less than two years, the trend is toward an increasing duration in the grant period.

An estimate of the funds required to support adequately the engineering sciences research endeavors over the next three or four year period resulted in the compilation of data shown on Figure 10. Information from the Health, Education and Welfare Agency as well as from ASEE studies resulted in the curves presented on the left hand side of Figure 10. These parameters were used in arriving at the estimates shown on the right hand side of Figure 10. The PhD enrollment in engineering is expected to climb to roughly 7,000 or 8,000 by 1968 and the engineering faculty needs will be close to 15,000 at that time. Clearly the need will be for faculty who are capable of directing PhD programs and dissertations. With the increasing graduate enrollment and the increase in faculty members who wish and need to be active in research, the Engineering Sciences Program anticipates a very sharp increase in the total demand for support of research

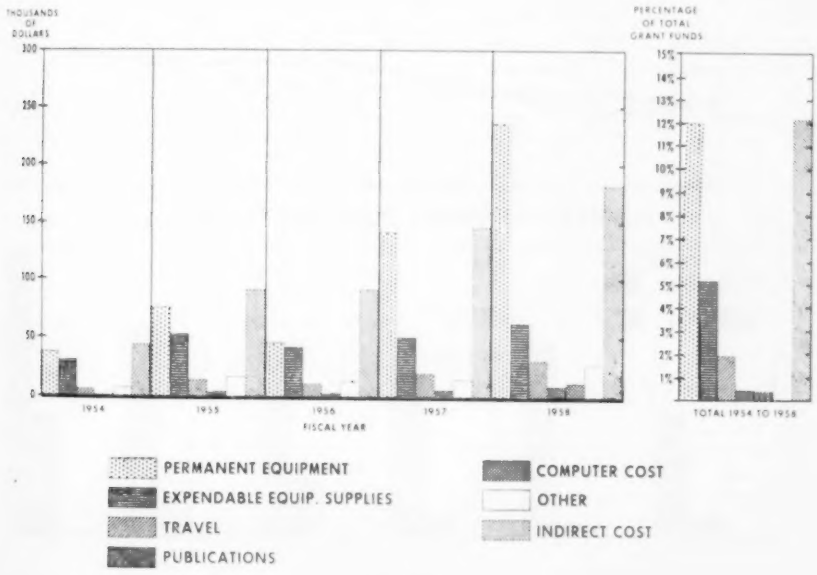

FIG. 7.

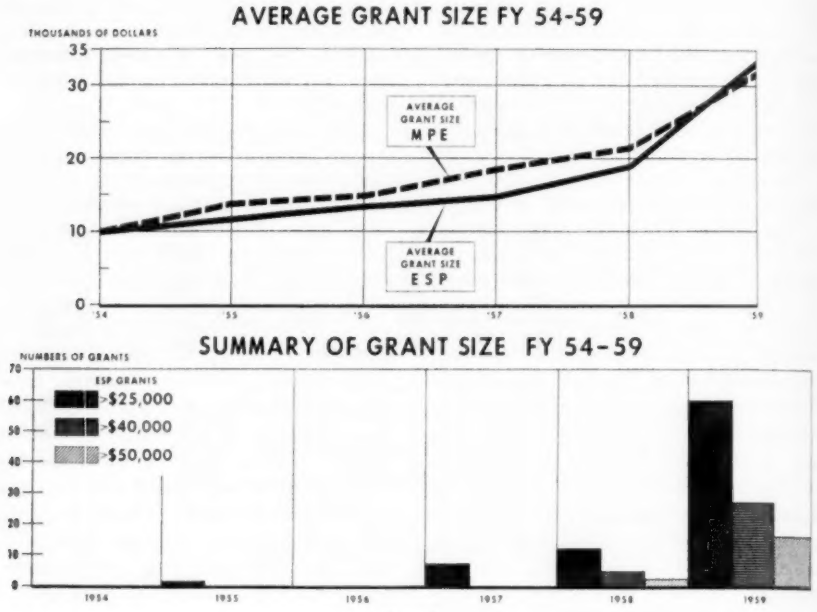
AVERAGE GRANT SIZE FY 54-59
THOUSANDS OF DOLLARS
35
30
20
10
0
AVERAGE GRANT SIZE MPE
AVERAGE GRANT SIZE ESP
'54
'55
'56
'57
'58
'59
SUMMARY OF GRANT SIZE FY 54-59
NUMBERS OF GRANTS
70
60
50
40
30
20
10
0
ESP GRANTS
>$25,000
>$40,000
>$50,000
1954
1955
1956
1957
1958
1959

FIG. 8.

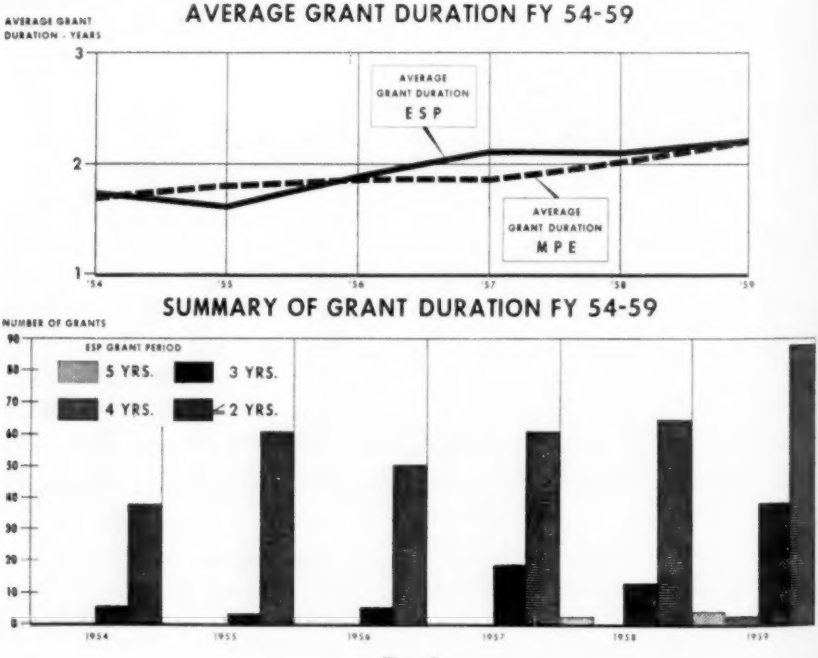
AVERAGE GRANT DURATION FY 54-59
AVERAGE GRANT DURATION - YEARS
3
2
1
AVERAGE GRANT DURATION ESP
AVERAGE GRANT DURATION MPE
'54
'55
'56
'57
'58
'59
SUMMARY OF GRANT DURATION FY 54-59
NUMBER OF GRANTS
90
80
70
60
50
40
30
20
10
0
ESP GRANT PERIOD
5 YRS.
3 YRS.
4 YRS.
2 YRS.
1954
1955
1956
1957
1958
1959

FIG. 9.

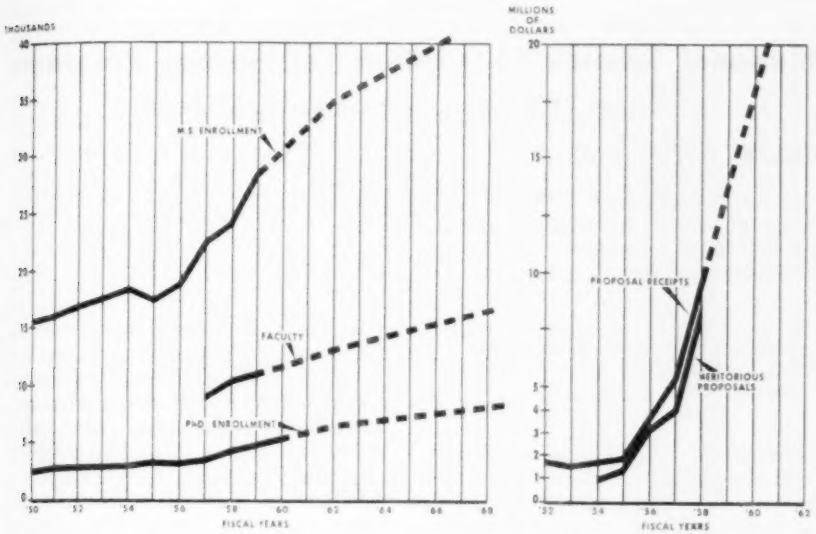

FIG. 10.

in the engineering sciences. If the solid portion of the curve is extended with data now available for 1959, the data for 1959 fall on the extrapolated portion of the curve, giving some credence to the curve for the anticipated need for research support. If, for example, it is desirable to support one out of three proposals for support of research in engineering sciences received, a budget of roughly 6 to 7 million dollars will be required in 1960 and perhaps 10 to 11 million dollars will be required by 1962.

Summary

In summary, the support of meritorious basic research is the principal objective of the Engineering Sciences Program grants. A corollary to this objective is the encouragement of increasing emphasis on graduate studies in the engineering sciences. Secondly, it is evident that the grants made during the past five years to the nation's universities have in fact been made to those which have, in great part, initiated an active research interest on their own part. This is demonstrated both by the figures indicating the number of dollars and grants made to departments within universities already offering the PhD degree and further by the figures indicating the numbers of dollars and grants to universities which expect their staff to contribute research and also give active support to the research activities of their staff members. A third and final point is that, because of the increasing emphasis on graduate work in the nation's engineering schools, a large increase in activities of the Engineering Sciences Program of the National Science Foundation is to be expected. In fact, it appears that within the next few years the support required for basic research in the engineering sciences may approximate that currently required for the entire Mathematical, Physical, and Engineering Sciences Division.

References

(1) "National Science Foundation Support of Engineering Sciences Research." JOURNAL, Vol. 49, No. 8, April 1959.

(2) "A Survey of Research in the Nation's Engineering Colleges – Capabilities and Potentialities"; July 1956 to June 1957.

National Science Foundation Fellowships Programs

Support of Training in Engineering Sciences

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Presented at the 67th Annual Meeting, ASEE, June 15–19, 1959, Pittsburgh, Pa.

Fellowships are an instrument of service to selected individuals in the form of grants to enable those individuals to further their scholarly pursuit of knowledge. They are investments in the future of individuals of high potential and are hence long-range investments in the future of our Nation. They are clearly distinct from grants designed to underwrite a specific project—research or development—and do not normally require any services to be rendered by the recipient.

The National Science Foundation supports seven fellowship programs at the graduate or postdoctoral levels, each designed to meet a specific need. Section 10 of the National Science Foundation Act authorizes the Foundation to offer fellowships and prescribes certain provisions that govern their administration. Among the latter are the following: (1) the Fellows shall be selected by the Foundation from among citizens of the United States solely on the basis of ability; (2) the Fellows shall have freedom of choice of their institutions from among appropriate nonprofit American or nonprofit foreign institutions; (3) when there are several applicants judged to be of substantially equal ability and there are insufficient funds to offer a fellowship to each, the awards will be offered in such a way as to achieve an equitable

TABLE 1

SUMMARY OF NATIONAL SCIENCE FOUNDATION FELLOWSHIPS

Fiscal Year	Graduate		Postdoctoral		Senior Postdoctoral		Science Faculty		Totals	
	Applicants	No. Fellows	Applicants	No. Fellows	Applicants	No. Fellows	Applicants	No. Fellows	Applicants	No. Fellows
1952	2,685	537	283	38	—	—	—	—	2,968	575
1953	2,930	498	368	24	—	—	—	—	3,298	522
1954	2,865	631	461	59	—	—	—	—	3,326	690
1955	2,931	657	458	53	—	—	—	—	3,389	710
1956	2,892	715	508	79	159	35	—	—	3,559	829
1957	3,028	773	482	85	304	48	416	100	4,230	1,006
1958	3,804	939	513	125	259	70	694	214	5,270	1,348
1959	4,506	1,100[1]	778	194[1]	241	83[1]	1,069	302[1]	—	—
	Cooperative Graduate		Graduate Teaching Assistants		Secondary School Teachers					
1959	2,872	1,050[1]	1,260	580[1]	1,578	628[1]	—	—	12,304	3,937[1]

[1] Awards offered in fiscal year 1959, as distinguished from acceptances in previous years.

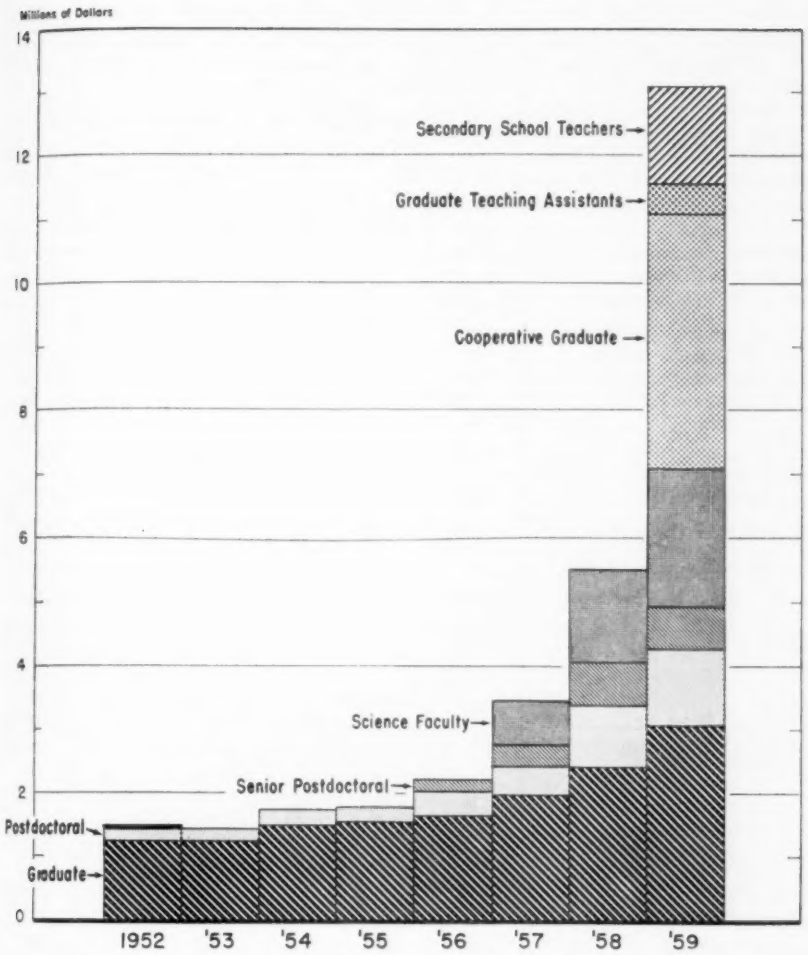

FIG. 1. Distribution of Fellowship Funds by Programs: Fiscal Years 1952–1959.

geographic distribution, and (4) the awards may be offered for scientific study or scientific work in the mathematical, physical, medical, biological, engineering and other sciences.

In the administration of its fellowship programs the Foundation, in addition, follows certain principles as a matter of policy. The essential features of policy are: (1) the selection of Fellows shall be made following, without exception, the advice of evaluation panels of highly competent scientists selected for this task by reputable national organizations; (2) because fellowships are long-range investments in the competence of individuals and not suitable mechanisms for meeting immediate shortages of specific kinds of scientific manpower, and because there is no way of accurately predicting the numbers of each kind of scientific specialists that will be needed, say, ten or twenty years hence, NSF fellowships are not awarded preferentially in any specific fields of science, and (3) all applicants in each program shall compete as individuals in a national competition.

TABLE 2

NATIONAL SCIENCE FOUNDATION GRADUATE, COOPERATIVE GRADUATE, TEACHING ASSISTANTS, POSTDOCTORAL, SENIOR POSTDOCTORAL AND SCIENCE FACULTY FELLOWSHIP PROGRAMS FOR FISCAL YEAR 1959

DISTRIBUTION OF APPLICANTS AND AWARDS OFFERED BY FIELD OF STUDY

Field	Graduate		Cooperative Graduate		Teaching Assistants	
	Applicants	Awards Offered	Applicants	Awards Offered	Applicants	Awards Offered
Physical Sciences						
Astronomy	43	13	12	5	2	0
Chemistry	787	201	580	205	368	162
Earth Sciences	283	75	161	50	80	39
Engineering Sciences	807	175	534	233	128	59
Mathematical Sciences	531	143	263	128	129	71
Physics	906	259	454	178	124	62
General	—	—	—	—	—	—
Sub-total	3,357	866	2,004	799	831	393
Life Sciences	1,041	216	785	238	369	165
Selected Social Sciences	108	18	83	13	60	22
Natural Sciences, General	—	—	—	—	—	—
Total	4,056	1,100	2,872	1,050	1,260	580

Field	Postdoctoral		Senior Postdoctoral		Science Faculty	
	Applicants	Awards Offered	Applicants	Awards Offered	Applicants	Awards Offered
Physical Sciences						
Astronomy	1	0	1	0	5	2
Chemistry	156	36	43	12	118	32
Earth Sciences	27	7	15	4	41	9
Engineering Sciences	12	3	19	5	294	83
Mathematical Sciences	54	30	16	6	209	58
Physics	102	42	34	13	111	33
General	—	—	—	—	12	1
Sub-total	352	118	128	40	790	218
Life Sciences	404	73	107	40	268	83
Selected Social Sciences	22	3	6	3	—	—
Natural Sciences, General	—	—	—	—	11	1
Total	778	194	241	83	1,069	302

The Seven Programs

Awarding fellowships is one of several approaches being used by the National Science Foundation in seeking solutions to the difficult and complex problems confronting the United States in science education and scientific and technological leadership. The seven fellowship programs currently supported by the National Science Foundation offer a wide range of opportunities for training to graduate students, advanced scholars, and college and secondary school teachers—all of which contribute to the Nation's scientific effort. Announcements and other literature on each program are

available upon request from the Foundation. These programs are summarized here as follows:

A. *Fellowships for Graduate Students*—(1) Graduate, (2) Cooperative Graduate, and (3) Summer Fellowships for Graduate Teaching Assistants.

The first two programs are designed to offer support to unusually able students, but differ in operational details and institutional participation. The third program is designed to enable selected graduate teaching assistants to devote full time in the summer to their own studies.

B. *Fellowships for Research Scientists*—(4) Postdoctoral and (5) Senior Postdoctoral.

These programs offer support to individuals who have received doctoral degrees and who immediately or some years later desire or need additional training to further improve their competence as research investigators.

C. *Fellowships for Teachers*—(6) Science Faculty and (7) Summer Fellowships for Secondary School Teachers of Science and Mathematics.

These programs offer support to teachers seeking further scientific training to increase their competence as teachers.

D. *Extramural Programs*—In addition to the seven National Science Foundation fellowship programs listed above, the Foundation is now engaged in a new, extramural type of fellowship activity, the administration of the North Atlantic Treaty Organization (NATO) Postdoctoral Fellowships in Science. This program has been funded by the Department of State. It appears likely that the Foundation will administer additional fellowship programs for other agencies and funded from sources other than National Science Foundation appropriations. Twenty NATO fellowship awards were made in May 1959 and it is assumed, at this time, that additional awards will be offered next year.

Of the seven NSF fellowship programs, three are new this year and were designed to fill specific needs—(a) Cooperative Graduate Fellowships and Summer Fellowships for (b) Graduate Teaching Assistants and (c) Secondary School Teachers. A summary of NSF fellowship programs is given in Table 1.

This table gives the applicants and Fellows in each program and the year each program was introduced. From fiscal year 1952 through 1955 there were but two fellowship programs (Graduate

TABLE 3

GRADUATE AND COOPERATIVE GRADUATE FELLOWSHIP PROGRAMS FOR FISCAL YEAR 1959

DISTRIBUTION OF AWARDS OFFERED BY FIELD AND LEVEL
(PHYSICAL SCIENCES)

Field	Graduate				Cooperative Graduate				
	First Year	Intermediate	Terminal	Total	First Year	Intermediate	Terminal	Total	Grand Total
Physical Sciences									
Astronomy	5	4	4	13	1	3	1	5	18
Chemistry	61	81	59	201	32	109	64	205	406
Earth Sciences	17	37	21	75	9	24	17	50	125
Engineering	80	74	21	175	117	82	34	233	408
Mathematics	56	61	26	143	28	54	46	128	271
Physics	95	103	61	259	30	101	47	178	437
Sub-total	314	360	192	866	217	373	209	799	1,665
Life Sciences	71	91	54	216	43	140	55	238	454
Selected Social	5	8	5	18	2	6	5	13	31
Total	390	459	251	1,100	262	519	269	1,050	2,150

TABLE 4

GRADUATE AND COOPERATIVE GRADUATE FELLOWSHIP PROGRAMS FOR FISCAL YEAR 1959

DISTRIBUTION OF ENGINEERING FELLOWSHIP APPLICANTS AND AWARDS OFFERED BY FIELD OF SPECIALIZATION

Field	Graduate Program		Cooperative Graduate Program	
	Applicants	Awards Offered	Applicants	Awards Offered
Electronic	193	43	61	30
Chemical	148	44	125	53
Mechanical	108	22	65	27
Electrical	93	19	59	34
Engineering (not elsewhere classified)	72	15	51	24
Nuclear	56	15	36	12
Civil	33	2	44	19
Aeronautical	28	7	24	10
Metallurgical	26	5	33	10
Industrial & Safety	18	1	12	4
Hydraulic	9	1	0	0
Sanitary & Public Health	7	0	2	1
Mining	6	1	1	1
Agricultural	5	0	8	3
Petroleum	4	0	3	1
Architectural	1	0	0	0
Ceramic	0	0	4	3
Instrumentation	0	0	3	1
Marine	0	0	3	0
Total	807	175	534	233

and Postdoctoral) in operation; in fiscal year 1956 the Senior Postdoctoral, in 1957 the Science Faculty, and in 1959 three new programs were introduced. The number of applicants and Fellows has increased from 2,968 and 575, respectively, in fiscal year 1952 to 12,304 and 3,937,[1] respectively, in 1959.

[1] It is anticipated that declinations, after awards have been offered, will amount to approximately 6% (varying from less than 2% in the Science Faculty program to as high as 15% in the Postdoctoral program) for all programs considered collectively, or that of the 3,937 awards offered, 3,700 will be accepted.

It is significant to note that there was a marked increase in applicants (4,506) in the Graduate program this year as compared to 1958 (3,804) and this despite the fact that 2,872 other applicants of substantially equal ability distribution applied in the new Cooperative Graduate program.

Many people have wondered if there were any advantages in applying in one over another of these programs. The Foundation operated these programs in such a way as to insure comparability in the evaluation of all applicants. There is one point which may not be self-evident from the table, namely, of the 1,100

TABLE 5

PART I

DISTRIBUTION OF ENGINEERING FELLOWSHIP APPLICANTS AND AWARDS OFFERED BY STATE OF PERMANENT RESIDENCE

State	Graduate Program		Cooperative Graduate Program	
	Applicants	Awards Offered	Applicants	Awards Offered
New York	141	27	64	38
California	97	20	41	21
Pennsylvania	77	14	38	17
Illinois	41	9	51	22
Massachusetts	39	9	15	6
Texas	31	8	16	6
Ohio	30	6	25	10
Michigan	29	12	26	11
New Jersey	26	5	21	11
Connecticut	21	5	8	5
Missouri	20	3	15	7
Washington	19	4	7	4
Wisconsin	19	4	16	6
Oklahoma	18	9	12	6
Maryland	16	2	13	5
Oregon	16	4	5	2
Colorado	15	4	4	0
Indiana	14	4	34	9
Iowa	11	4	13	7
Kansas	11	3	6	3
Sub-total	691	156	430	196
Other states	116*	19	104**	37
Total	807	175	534	233

* 29 states represented.
** 24 states represented.

TABLE 5—*Continued*

GRADUATE AND COOPERATIVE GRADUATE FELLOWSHIP PROGRAMS FOR FISCAL YEAR 1959

PART II

DISTRIBUTION OF ENGINEERING FELLOWSHIP APPLICANTS AND AWARDS OFFERED

State	Graduate Program		Cooperative Graduate Program	
	Applicants	Awards Offered	Applicants	Awards Offered
Alabama	5	1	5	2
Arizona	3	1	3	3
Arkansas	5	0	0	0
Delaware	5	1	4	1
District of Columbia	2	0	4	1
Florida	10	3	8	3
Georgia	4	0	5	1
Hawaii	4	2	1	1
Idaho	3	1	6	1
Kentucky	4	2	5	3
Louisiana	9	0	6	3
Maine	2	1	2	0
Minnesota	5	1	10	2
Mississippi	4	0	2	1
Montana	5	0	0	0
Nebraska	3	1	6	1
Nevada	2	0	0	0
New Hampshire	2	0	0	0
New Mexico	4	0	2	1
North Carolina	9	1	5	1
North Dakota	1	0	1	1
Rhode Island	2	0	1	0
South Carolina	2	0	3	0
South Dakota	0	0	5	2
Tennessee	5	1	4	1
Utah	3	1	4	4
Vermont	2	1	0	0
Virginia	8	0	10	3
West Virginia	2	1	0	0
Wyoming	1	0	2	1
Sub-total	116	19	104	37
Total	807	175	534	233

awards in the Graduate program, 549 were to renewal applicants and 551 to new applicants. Since there were 3,857 new applicants, the ratio of awards to applicants in this "new" group was 1 : 7, representing one of the keenest competitions for new awards in the history of the NSF predoctoral fellowship program.

Financial Support

The financial support for NSF fellowship programs is shown in Figure 1. In fiscal year 1952 approximately $1.45 million was spent, whereas in 1959 we estimate that approximately $13 million will be spent. It is evident that the major growth in financial support corresponds to the expansion into new fellowship program areas in fiscal year 1959. We estimate that the seven NSF programs in 1960 will operate at approximately the same levels as in 1959.

In the fiscal year 1959 programs, it is significant to note, as given in Table 2, the extent to which applicants in the engineering sciences participated. In the Graduate and Cooperative Graduate programs, 408 of the 1,341 applicants in engineering sciences were offered awards. When this number of awards offered in a single year's competition is compared to the total number of Ph.D.'s (about 600) granted in engineering per year, this reflects a very favorable support level. On the other hand, if the 408 awards are compared to the 35,000 engineering graduates (B.S.) per year, the figure is less significant. We hope that more high-ability students in engineering apply for NSF fellowships in future years.

Engineering applicants in the Postdoctoral and Senior Postdoctoral programs were limited but awards were made to engineers in both programs.

The participation of teachers of engineering in the Science Faculty program is worthy of special note. In this program, more teachers of engineering applied (294) and received awards (83) than any other group of teachers. Many of the award winners will be in degree programs on an academic year basis while others will use their fellowships to go to school for as many as three consecutive summers. Other general relationships will be evident upon study of Table 2.

One of the more significant aspects of the participation of engineering students

in the Graduate and Cooperative Graduate programs is given in Table 3.

In this table applicants receiving awards are grouped by field and year level. Of the 408 engineering applicants offered awards, 197 (or 48.3%) would be at the first-year level during the academic year 1959–60—thus, each of these programs has served to support "new blood." The number of first-year level engineering awardees (117) in the Cooperative Graduate program is of particular significance in itself as well as when compared with other levels and scientific disciplines.

It is perhaps appropriate to explain at this point that applicants in the Cooperative Graduate program apply through graduate schools of their choice; the institutions evaluate all applicants and then forward all applications to the NSF along with a rank ordered list of their recommended applicants and a list of all non-recommended applicants. All applications are further evaluated by a central panel, which takes into account the institutions' evaluations, and the Foundation then selects the awardees, based on the recommendations of the central panel

TABLE 6

NATIONAL SCIENCE FOUNDATION GRADUATE FELLOWSHIP PROGRAM FOR FISCAL YEAR 1959

PART I

B.A. INSTITUTIONS OF FIRST YEAR ENGINEERING AWARDEES

Institution	Awardees
Massachusetts Institute of Technology	4
Purdue University	4
Yale University	4
College of the City of New York	3
Harvard University	3
Oklahoma State University of A. & A.S.	3
Pennsylvania State University	3
Rensselaer Polytechnic Institute	3
Rice Institute	3
University of Michigan	3
Cornell University	2
Northwestern University	2
Stanford University	2
University of California (Berkeley)	2
University of Kansas	2
University of Notre Dame	2
Washington University	2
Sub-total	47
33 other institutions	33
Total	80

TABLE 6—*Continued*

PART II

B.A. INSTITUTIONS OF FIRST YEAR ENGINEERING AWARDEES

Institution	Awardees
Brown University	1
Bucknell University	1
California Institute of Technology	1
Carnegie Institute of Technology	1
Colorado State University	1
Cooper Union	1
Dartmouth College	1
Illinois Institute of Technology	1
Iowa State College	1
Kansas State College of A. & A.S.	1
Lafayette College	1
Princeton University	1
Rutgers, The State University	1
St. Louis University	1
State University of Iowa	1
Texas Technological College	1
Union College & University	1
University of Arizona	1
University of Cincinnati	1
University of Delaware	1
University of Detroit	1
University of Florida	1
University of Hawaii	1
University of Houston	1
University of Miami	1
University of Nebraska	1
University of Oklahoma	1
University of Rochester	1
University of Southern California	1
University of Texas	1
University of Washington	1
Vanderbilt University	1
Virginia Polytechnic Institute	1
Sub-total	33
Total	80

and in accordance with statutory requirements. A special feature of the Cooperative Graduate program is that each institution receives $1,800 to aid in covering costs of education of the Fellow, including tuition and required fees. This program is designed in such a way as to insure a wider distribution of support and strengthening of graduate institutions on a broadened institutional base.

Distribution

The distribution of engineering Graduate and Cooperative Graduate fellowship applicants and awards offered in fiscal year 1959, by fields of specialization, is given in Table 4.

TABLE 7

NATIONAL SCIENCE FOUNDATION COOPERATIVE GRADUATE FELLOWSHIP PROGRAM FOR FISCAL YEAR 1959

PART I

B.A. INSTITUTIONS OF FIRST YEAR ENGINEERING AWARDEES

Institution	Awardees
Massachusetts Institute of Technology	9
Purdue University	8
University of Michigan	7
Case Institute of Technology	4
Drexel Institute of Technology	4
Iowa State College of Agriculture and Mechanic Arts	4
Michigan State University of Agriculture and Applied Science	4
Rensselaer Polytechnic Institute	4
University of Illinois	4
University of Utah	4
University of Wisconsin	4
Columbia University	3
Cornell University	3
North Carolina State College of Agriculture and Engineering	3
Polytechnic Institute of Brooklyn	3
University of California (Berkeley)	3
University of Washington	3
Sub-total	74
33 other institutions	43
Total	117

TABLE 7—*Continued*

PART II

B.A. INSTITUTIONS OF FIRST YEAR ENGINEERING AWARDEES

Institution	Awardees
California Institute of Technology	2
Illinois Institute of Technology	2
Lehigh University	2
New York University	2
Ohio State University	2
Oklahoma State University	2
Stanford University	2
University of Florida	2
University of Maryland	2
Washington University	2
Chico State College	1
College of the City of New York	1
Georgia Institute of Technology	1
Johns Hopkins University	1
Louisiana State University and Agricultural and Mechanical College	1
Miami University	1
Missouri School of Mines	1
Northwestern University	1
Oregon State College	1
Princeton University	1
Tulane University	1
University of Akron	1
University of Arizona	1
University of Connecticut	1
University of Houston	1
University of Kansas	1
University of Kentucky	1
University of New Mexico	1
University of North Dakota	1
University of Pennsylvania	1
University of Wyoming	1
Utah State University of Agriculture and Applied Science	1
Virginia Polytechnic Institute	1
Sub-total	43
Total	117

The fields of specialization listed are those designated by the applicants and, therefore, are not a classification of applicants by the Foundation. The information in this table—and in other tables to follow—is arranged in such a way as to make possible the ready comparison between the two predoctoral programs,

their applicants and awards, using the older program (Graduate) as the base. Many interesting comparisons between fields of specialization are evident. The overall significant point appears to be that the number of engineering awards in the Cooperative Graduate program is much larger than in the Graduate program.

Each year, as an integral part of the Foundation's work and in an attempt to make pertinent information available to all interested parties, we bring together additional data on the geographic distribution of applicants and awardees, the baccalaureate origin of awardees, and a list of institutions the awardees plan to attend. Although some awardees change to other schools for a number of reasons, for purposes of presenting information on our fiscal year 1959 operations, these changes could not be taken into account.

The distribution of engineering Graduate and Cooperative Graduate fellowship applicants and awards by State of permanent residence is given in Table 5.

In the Graduate program, applications were received from people in 49 States,

TABLE 8

NATIONAL SCIENCE FOUNDATION GRADUATE AND COOPERATIVE GRADUATE FELLOWSHIP PROGRAMS FOR FISCAL YEAR 1959

PART I

INSTITUTIONS CHOSEN BY ENGINEERING APPLICANTS OFFERED AWARDS

Institution	Graduate Program		Cooperative Graduate Program	
	First Year	Combined Levels	First Year	Combined Levels
Massachusetts Institute of Technology	21	46	11	23
Stanford University	7	20	3	12
University of Michigan	7	18	5	11
California Institute of Technology	7	12	2	6
Harvard University	5	10	0	1
University of California (Berkeley)	5	10	3	11
Carnegie Institute of Technology	0	8	1	3
Cornell University	2	4	4	11
Oklahoma State University of Agriculture and Applied Science	3	3	2	2
Princeton University	3	3	2	4
Rice Institute	3	3	0	3
University of Florida	2	3	2	2
Illinois Institute of Technology	1	2	2	5
Johns Hopkins University	1	2	2	2
Polytechnic Institute of Brooklyn	1	2	3	3
Purdue University	1	2	8	12
Rensselaer Polytechnic Institute	0	2	4	4
University of Delaware	0	2	0	6
University of Illinois	0	2	5	10
University of Kansas	1	2	1	1
Sub-total	70	156	60	132
45 other institutions	10	19*	57	101**
Total	80	175	117	233

* 17 institutions represented.
** 38 institutions represented.

TABLE 8—*Continued*

PART II

INSTITUTIONS CHOSEN BY ENGINEERING APPLICANTS OFFERED AWARDS

Institution	Graduate Program		Cooperative Graduate Program	
	First Year	Combined Levels	First Year	Combined Levels
University of Minnesota	0	2	0	2
University of Oklahoma	1	2	0	2
Brown University	1	1	0	1
Colorado School of Mines	0	1	0	0
Columbia University	0	1	5	8
Dartmouth College	1	1	—	—
Iowa State College of A. & M.A.	0	1	4	7
Kansas State College of A. & A.S.	1	1	0	0
Ohio State University	0	1	3	6
State University of Iowa	1	1	0	0
University of Arizona	1	1	1	1
University of Houston	1	1	1	2
University of Nebraska	1	1	0	0
University of Pennsylvania	1	1	1	3
University of Southern California	1	1	0	0
University of Texas	0	1	0	0
Yale University	0	1	0	4
Case Institute of Technology	0	0	3	3
Georgia Institute of Technology	0	0	2	2
Lehigh University	0	0	1	2
Michigan State University of A. & A.S.	0	0	5	7
New York University	0	0	2	2
North Carolina State College of A. & E.	0	0	3	4
Northwestern University	0	0	1	4
Oregon State College	0	0	1	1
Pennsylvania State University	0	0	1	5
Rutgers, The State University	0	0	0	1
Tulane University	0	0	1	1
University of California (Los Angeles)	0	0	0	1
University of Connecticut	0	0	1	1

Territories and the District of Columbia, but only 44 were represented in the Cooperative Graduate program. This latter situation probably arose from the fact that the Cooperative Graduate program was new this year. For purposes of presentation, we have arbitrarily arranged the first part of Table 5 in order of descending number of applicants in the Graduate program, and have used as a cut-off point 11 applicants; the balance of Table 5 has been arranged in alphabetical order by State. This method of presentation is solely for the purpose of focusing attention on differences between the two programs and is intended in no way to reflect on applicants from any State. Indeed, these data will vary from year to year, but they are presented in the hope that others interested in the educational problems of the Nation will find them of value. In the Graduate program, the persons from the first twenty States listed in Table 5 account for 85.6% of the engineering applicants and 89% of the awardees; in the Cooperative Graduate program the figures are 80.5% and 84%, respectively.

TABLE 8—*Continued*

PART III

INSTITUTIONS CHOSEN BY ENGINEERING APPLICANTS OFFERED AWARDS

Institution	Graduate Program		Cooperative Graduate Program	
	First Year	Combined Levels	First Year	Combined Levels
University of Kentucky	0	0	1	1
University of Louisville	0	0	0	1
University of Maryland	0	0	2	2
University of Missouri	0	0	1	1
University of New Mexico	0	0	1	1
University of North Dakota	0	0	1	1
University of Notre Dame	0	0	0	2
University of Tennessee	0	0	0	1
University of Utah	0	0	4	4
University of Washington	0	0	1	2
University of Wisconsin	0	0	5	8
University of Wyoming	0	0	1	1
Utah State University of A. & A.S.	0	0	1	1
Virginia Polytechnic Institute	0	0	1	1
Washington University	0	0	2	4
Sub-total	10	19	57	101
Total	80	175	117	233

In Table 5, the data are for engineering applicants and awardees at all graduate levels. Data on baccalaureate origin of first-year-level awardees are given in Table 6 for the Graduate program and Table 7 for the Cooperative Graduate program. Although 50 institutions are represented in each program, only twenty are represented in both programs, and for this reason separate tables have been prepared. Thus, a total of 80 institutions are represented in the two programs. The tables are set up in descending order of awardees from each institution and are arbitrarily broken at the first 17 institutions for comparison purposes. Of the 17 institutions, only 12 are common to both lists but these are not necessarily in the same order. The fact that applicants from 30 different institutions were successful in the Cooperative Graduate program as compared to the older Graduate program would emphasize that capable students are present in other schools and perhaps what the Foundation has done is to broaden the base for participation by giving the cooperating institutions an opportunity to analyze their own needs more clearly. The Foundation is not evaluating institutions, however, but rather reporting the results of a single year's competition.

Now, where do engineering applicants who are offered awards say they wish to attend school? For the fiscal year 1958 Graduate and Cooperative Graduate programs, this question is answered in Table 8. As mentioned earlier, this listing is subject to change by declinations and changes in institutions for a number of reasons once the awards are offered. In order to give as complete information as possible, both the first-year level and combined-level awardees are given. For purposes of presentation, Table 8 has been arbitrarily divided into two parts, the first part consisting of a listing in descending order of combined year level awardees for the first 20 institutions in the Graduate program, and the second part by alphabetical order by descending awardees. Thus, for comparison pur-

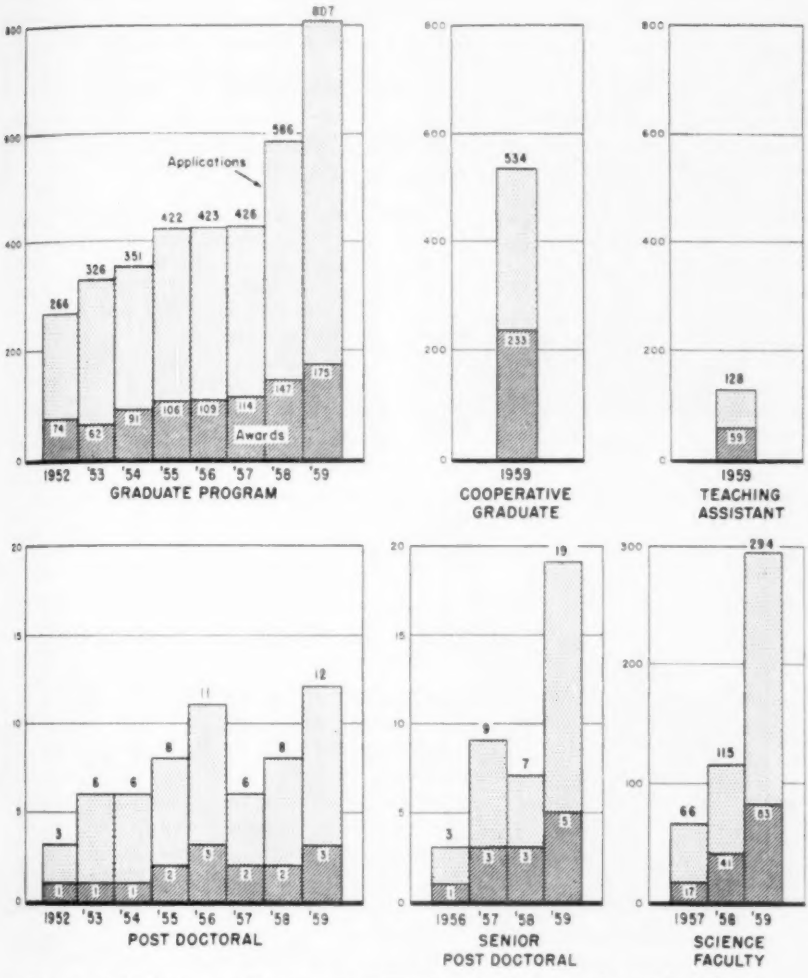

FIG. 2. Distribution of Engineering Fellowship Applicants and Awards Offered: Fiscal Years 1952–1959.

poses, the awardees in the Cooperative Graduate program follow the same institutional list but not the same order of awardees list. In the Graduate program there are 37 institutions indicated by awardees whereas in the Cooperative Graduate program 58 institutions are represented. It should be mentioned that Dartmouth College was not eligible to compete in the Cooperative Graduate program. Engineering awardees designating the first six institutions listed in Table 8 as their proposed institution account for 66.3% of the combined-year level awardees and 65% of first year level awardees in the Graduate program. By contrast, awardees choosing the same institutions in the Cooperative Graduate program amount to only 27.4% and 20.5%, respectively. It must be remembered that, although it had been hoped that the Cooperative Graduate program would produce a wider distribution in all fields, we could not have predicted in

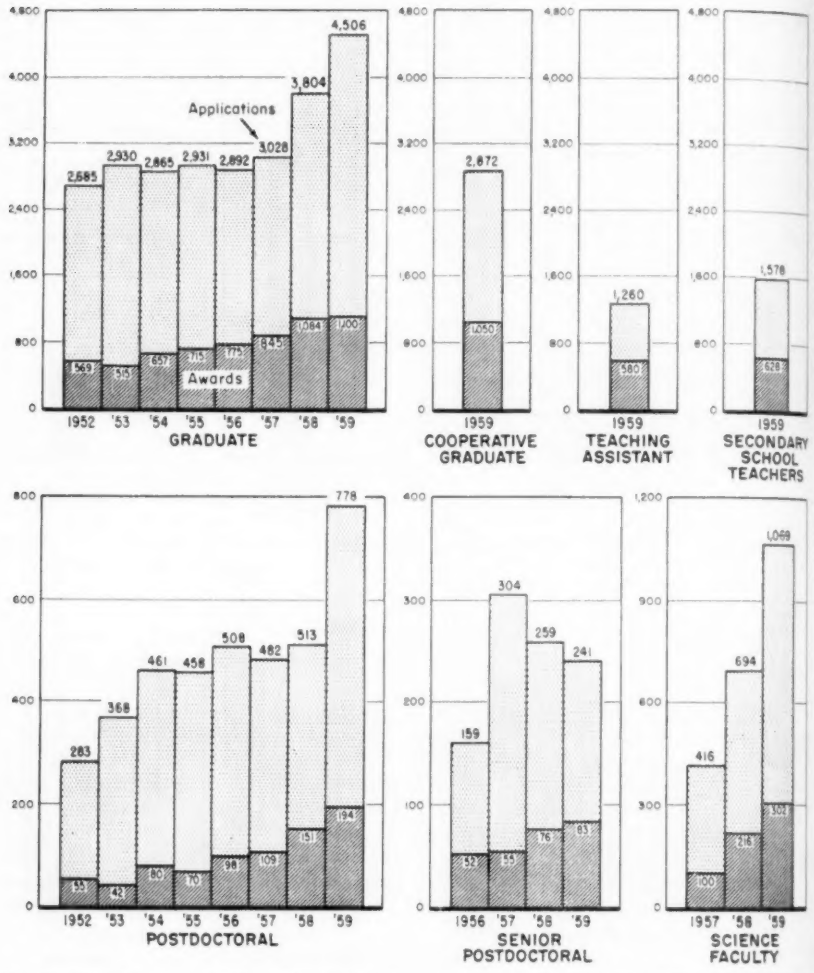

FIG. 3. Distribution of Fellowship Applicants and Awards Offered: Fiscal Years 1952–1959.

advance that the distribution of engineering awardees would have been as given in Table 8. Neither could it have been predicted that more awards would go to engineering applicants than to any other discipline. Many of the results obtained in this year's competition may not be reflected in other disciplines and studies are currently under way to make available similar data in other fields.

In summary, it can be stated that engineering applicants have competed favorably with applicants in other fields for NSF Fellowships, especially in the predoctoral and science faculty programs; the engineering community has become better acquainted with the opportunities offered in the fellowship programs; and the steady and progressive increase in participation by engineer applicants since fiscal year 1952 shows a real awakening to the problems confronting them as a group. Just how engineer applicants have fared from 1952 through 1959 is shown in Figure 2. If one wishes to relate these figures to the total competition

in any one year, the necessary data will be found in Figure 3. The data in Figure 3 serve another useful purpose in that by subtracting the number of Fellows (given in Table 1) from the awards offered for each year in each program, the declinations in each program will be obtained.

The National Science Foundation fellowships are designed to encourage excellence in individuals, irrespective of scientific field or financial need, and it is hoped that they will serve as a friendly competitive force in our educational system. Selection of the very best individuals from among the many thousands of capable people who apply, on their own initiative, continues to challenge the Foundation. There are insufficient predictors to guarantee an absolute degree of selection of "sure winners" only, but on the basis of available information and information obtained through research on selection techniques supported by the Foundation, we strive to identify those highly capable individuals and provide them with reasonable financial support for their scientific development. Because the stakes are high and the Nation can ill afford to put too little emphasis on science training and its engineers, mathematicians and scientists in this competitive era, we hope that our combined fellowship programs will have a significant and favorable impact on science in the United States.

GRAHAM NEW DEAN AT ROCHESTER

Plans for expanding the teaching, research, and service programs of the new College of Engineering at the University of Rochester have been disclosed with the appointment of Dr. John W. Graham, Jr., formerly vice president of The Cooper Union for the Advancement of Science and Art, New York City, as Dean of that College.

Dr. Graham began his new duties July 1, 1959. He will also be responsible for increasing space in Gavett Hall, home of the College of Engineering, and adding to faculty.

Engineering began at Rochester nearly 50 years ago and there are now 1,600 graduates of the program. When the first three degrees were awarded in 1914, all were in mechanical engineering. Today the University offers the bachelor's and master's degrees in mechanical, chemical and electrical engineering, and the Ph.D. degree in chemical engineering. Prior to September, 1958, these three departments made up the Division of Engineering, which in turn was a part of the College of Arts and Science. As of that date, however, it assumed independent status as the College of Engineering.

Fourth Engineering Technician Survey of Enrollments and Graduates 1957-1958 and 1958-1959

This fourth survey of engineering technician enrollments and graduates was undertaken after a lapse of three years. Usable data were collected from 207 schools for the years 1957–1958 and 1958–1959. Thirty-five of these schools have engineering technician curricula accredited by ECPD. The last previous survey was conducted for 1955–1956.

Full-time enrollments, Table I, in 1958–1959 increased 10% to 43,902 with ⅔ of the schools reporting increases over 1957–1958. ECPD-accredited curricula increased 6% with 60% of the institutions reporting increased enrollments.

TABLE I

ENGINEERING TECHNICIAN ENROLLMENTS

Institutions Offering at Least One Engineering Technician Curriculum Accredited by ECPD

	1957–1958		1958–1959	
	Students	Institutions	Students	Institutions
Full-Time	16,606	35	17,554	35
Part-Time	5,641	18	6,814	18
Total:	22,247	35	24,368	35
Institutions Identified by the NSTIE* as Offering Engineering Technician Curricula				
Full-Time	15,545	64	17,593	68
Part-Time	24,056	46	23,714	48
Total:	39,601	75	41,307	75
Other Institutions Offering Engineering Technician Curricula				
Full-Time	7,664	86	8,755	92
Part-Time	3,803	38	4,109	45
Total:	11,467	97	12,864	97
Totals All Institutions				
Full-Time	39,815	185	43,902	195
Part-Time	33,500	102	34,637	111
Totals	73,315	207	78,539	207

* NSTIE: National Survey Technical Institute Education—conducted by Technical Institute Division of ASEE.

TABLE II

ENGINEERING TECHNICIAN GRADUATES

Institutions Offering at Least One Engineering Technician Curriculum Accredited by ECPD

	1957–1958		1958–1959	
	Graduates	Institutions	Graduates*	Institutions
Full-Time	5,385	34	5,809	34
Part-Time	543	12	669	12
Total:	5,928	35	6,478	35
Institutions Identified by the NSTIE as Offering Engineering Technician Curricula				
Full-Time	4,017	59	4,798	62
Part-Time	1,341	27	1,554	28
Total:	5,358	75	6,352	75
Other Institutions Offering Engineering Technician Curricula				
Full-Time	1,727	74	2,292	80
Part-Time	419	16	505	20
Total:	2,146	97	2,797	97
Totals All Institutions				
Full-Time	11,129	167	12,899	176
Part-Time	2,303	55	2,728	60
Totals	13,432	207	15,627	207

* Estimated.

The 207 schools reported total full-time and part-time engineering technician enrollments of 78,539.

Full-time graduates, Table II, were estimated to increase 16% to 12,899 in 1958–1959 with the total full-time and part-time to be 15,627. Seventy per cent of the 176 institutions reporting full-time graduates expected an increase over 1957–1958. It is generally believed that graduates who have attended school on a part-time basis do not materially affect the available engineering technician supply since most are fully employed while attending school. They, also, represent less than 20% of the total while part-time enrollments are nearly 45% of the total.

For this survey 556 schools were contacted with 388 replies being received. Forty-eight could not be used for one reason or another. One hundred and thirty-three institutions reported that no engineering technician curricula were offered. Replies indicated information on part-time students frequently was not readily available. Data on part-time graduates was most often omitted.

Of some significance is the wide range in enrollments of the various schools. Only eight reported enrollments of more than 1,000 full-time students while more than one-half reported less than 100. The peak was 1961 with one institution reporting only 1 full-time enrollment. The number of graduates from full-time attendance showed a similar wide range from 0 graduates to 900. Seven schools anticipated more than 300 graduates each, while 85% expected less than 100.

It appears that more and more schools are offering programs for engineering technicians but with only slight effect on the trained technical manpower supply. Since 1955–1956 an increase of 40% in number of schools reporting shows slightly over 30% increase in enrollment and only a 2% increase in number of graduates.

DONALD C. METZ, *Chairman*

Manpower Studies
Technical Institute Division
American Society for
Engineering Education

June 12, 1959

OHIO STATE UNIVERSITY GIVES COLLEGE OF ENGINEERING PROFESSIONAL STATUS

An academic reorganization of the Ohio State University College of Engineering was approved July 10, 1959, by the university's Board of Trustees.

Major changes included establishment of a Pre-Engineering Division for the first two years of pre-professional study and a Professional Division for the last three years of the five-year program. Graduation requirements are based on the successful completion of the work of the Professional Division. The curricular changes went into effect in the Autumn Quarter.

The pre-engineering curriculum will be common for all branches of engineering, with the exception that students who expect to enroll in any of the chemically based curricula in the Professional Division will schedule two courses in quantitative analysis which would not be required of students who enter any of the other professional curricula. The program in pre-engineering will include work in English, mathematics, physics, chemistry, engineering drawing and engineering mechanics. Also included is the equivalent of nearly one quarter's work in the humanities and social sciences and the university requirements in physical education and military science. Admission to the Professional Division will be contingent upon completion of this work, or its equivalent, with an average grade of "C" or better.

Why They Quit Teaching

Report of Ad Hoc Committee on Loss of Faculty to Industry
June 19, 1959

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In 1956, a survey was made by a Committee of the Relations with Industry Division of ASEE on the migration of faculty between campus and industry. Some 90 engineering colleges returned questionnaires which were analyzed and reported at the 1956 Annual Meeting. The results were published in the October, 1956, JOURNAL.

The consensus of deans generally was that if plenty of money were available for salaries there would be no serious problem in retaining well-qualified teaching staffs. Various opinions, however, pointed up the need to continue this study by asking a number of former teachers themselves the reasons why they were attracted away from teaching for other employment.

On the recommendation of the general council of the Society in 1957, President W. L. Everitt established the *ad hoc* Committee on Loss of Faculty to Industry, to explore further the factors related to the problem. About this same time, the Committee on Development of Engineering Faculties began its work on that important subject. Dr. Harold L. Hazen, Chairman, has served also on the *ad hoc* Committee to assure coordination of effort. Members of the Relations with Industry Division have provided the important constitutent of man hours to prepare, distribute, and analyze the questionnaires used in the survey, and at various times the encouragement of ECAC has made the assignment appear meaningful.

At the 1957 Annual Meeting, Professor L. H. Lamouria reported to the *ad hoc* Committee on a survey that a Committee of the Pacific Southwest Section made with teachers who left colleges in that section for other employement. This provided helpful background for the proposed undertaking on a national level.

Agreeing on procedures and a questionnaire, and getting usable names and addresses of former teachers, took up the time of the Committee until the summer of 1958.

The Chairman wishes to thank the members of the Committee who have helped with various aspects of the study, and to give special mention to Lee R. Baker and J. Stuart Johnson whose aid in analyzing the questionnaires has made this report possible; also to thank The Detroit Edison Company and The University of Michigan for the cooperation and services that proved so valuable and helpful for the study and report.

Number of Colleges Reporting

The following quote from the letter mailed April, 1958, to the Deans on the ASEE's mailing list describes the teacher that was included in the survey.

"To accomplish such a survey, will you please supply the Committee with a list of names and present addresses of engineering teachers as specified below who have left

your campus for employment *other than teaching* since June, 1954, and the date of leaving. Please include only those individuals who meet all of the following qualifications:

1. Those of whose present address you are reasonably sure.
2. Those defined as in the recent survey of engineering faculty needs as follows:

   A member of the engineering faculty is a person on the staff of the engineering college or division who teaches engineering or engineering science subjects (as defined in the report of the Committee on Evaluation of Engineering Education) to engineering students. Persons on the engineering college faculty who teach other subjects (such as basic science and mathematics or the humanities) and those in other divisions of the university who may teach engineering students are not included in this definition.
3. Those who were employed full time and primarily as teachers although some proportion of their time may have been devoted to research or other academic duties, with some part of salary supplied by contract research or other budget.
4. Those whom you consider as properly qualified for reemployment as engineering teachers."

Seventy-seven replies from colleges supplied the Committee with 591 names and addresses to each of whom a letter and a questionnaire were mailed. Inasmuch as the Pacific Southwest Section had experienced the preliminary survey referred to above, this survey does not include any former teachers from that section.

Replies from Former Teachers

Usable replies were received from 235, approximately 40%. In view of the length and nature of the questionnaire, this is considered an excellent response. Approximately 30 were received which, for various reasons, were not reviewed or included in the report.

The replies are not identified by the name of the respondent, but the questionnaires were coded when distributed according to the following symbols, using the same or a similar terminology, to that adopted by a "Survey of Engineering Faculty Needs," by the Committee on Development of Engineering Faculties:

ASEE Section	*Identifying Group Symbol Used in This Report*
New England Upper New York–Ontario	A
Middle Atlantic National Capital Area Allegheny	B
Southeastern	C
Michigan Ohio Illinois–Indiana	D
North Midwest Kansas–Nebraska	E
Southwest Rocky Mountain Pacific Northwest University of Hawaii	F

Type of Community:

U for Urban—School located in or near a large city area.

N for Non-Urban—School located in a small town or city with little business, other than education.

Type of Institution:

I. Endowed	1. University
II. State Supported	2. College
III. Municipal	3. Polytechnic Institute
IV. Military	

When such use will save space, these codes are used in the report and tables.

The use of the word "Industry" is done for purposes of convenience. Former teachers represented in this study include some who left teaching for employment by government agencies, for consulting practice and university research, and personal business, as well as those who are working in industry or private research organizations.

Limitations of Report

It is well to observe at this point that the questionnaires contain data that might be assembled and analyzed in many different ways. The Committee has made some observations by ASEE section groups A to F.

Should any special interest group of the Society wish to study the questionnaires further to observe some particular feature, the records can be made available. Limitations of this report have been determined by time and volunteer man-hours available for analysis.

While it has been necessary for the Committee to do some interpreting when analyzing and classifying the opinions and statements in the questionnaires, further interpretation of their significance will generally be left to each reader. As might be expected from a survey of this kind, teachers express a wide variety of reasons why they have turned to other employment. Some reasons, it will be observed, are more prevalent than others. The significance of every opinion, however, should not be underestimated. Our subjects are people as well as teachers and merit considerations in that respect the same as employees in any other situation.

TABLE 1-A

DISTRIBUTION BY ASEE

Identifying Group		Section Groups and Type of Institution													Total
		Non-Urban					Urban								
		I		II			I			II			III	IV	
		1	3	1	2	3	1	2	3	1	2	3	1	1	
A	x	2	1	3			5		2						13
	y	6	6	16			29		46						103
	z	3	2	8			7		25						45
B	x	1		3			7		4		1		1		17
	y	3		50			41		15		5		19		133
	z	0		14			15		2		3		5		39
C	x	1	1	1	3	1	2			3	1	1			14
	y	9	8	3	13	20	13			28	17	9			120
	z	1	3	3	4	9	7			11	9	6			53
D	x			2			3	1	1	3			2	1	13
	y			44			14	2	20	29			7	6	122
	z			22			6	0	6	17			1	3	55
E	x			4	3					2					9
	y			28	21					14					63
	z			10	8					0					24
F	x			2	2	1	3			3					11
	y			15	4	12	9			10					50
	z			6	2	1	6			4					19
Total	x	4	2	15	8	2	20	1	7	11	2	1	3	1	77
Total	y	18	14	156	38	32	106	2	81	81	22	9	26	6	591
Total	z	4	5	63	14	10	41	0	33	38	12	6	6	3	235

(Total non-urban z — 96) (Total urban z — 139)

Code:

(x) Number of schools supplying names and addresses.
(y) Number of names and addresses of former teachers.
(z) Number of questionnaires returned and analyzed.

TABLE 1–B

Number of Years of Teaching	Age at Time of Leaving Campus							
	Up to 25	26 to 30	31 to 35	36 to 40	41 to 45	46 to 50	51 and over	Total
1 to 2	20	16	13	4				53
3 to 5	1	28	28	10	2			69
6 to 10		9	35	22	9	1		76
11 to 15			3	15	3	1	1	23
16 or more				1	5	3	5	14
Totals	21	53	79	52	19	5	6	235

Diversity of Schools Represented

Table 1–A indicates that the schools of the respondents are well scattered throughout the United States and that different types of institutions are represented in the replies.

Statistics by Age and Years of Teaching

Table 1–B shows the relationships between age at time of leaving the campus and number of years of teaching.

Summary of other background information for the 235 teachers:

Number who were considered permanent members of their faculties 189

Highest degree attained:

Bachelors	26
Masters	127
Doctors	82

Rank at time of leaving:

Instructors	64
Assistant Professors	95
Associate Professors	50
Professors, Department Heads, or Lecturers	26

Number who had previous industrial experience as an engineer 164

On making the overtures for a new position:

Did present position seek you	72 said "yes"
Did you seek a new position	145 said "yes"

With respect to duties in the new positions, research, development, design, management, and administration were the most frequent answers, and in that order.

Part II of the questionnaire asked questions relative to extracurricular activities. Those that were answered yes or no are summarized as follows:

	Yes	*No*
Did your institution encourage research?	174	50
Did you feel under pressure to do research?	79	139
Did your institution permit professional consulting?	220	8
Did your institution encourage publications?	202	24
Did you feel under pressure to do so?	80	141
Were you given administrative assignments?	177	57
If yes, were these:		
(a) an opportunity to contribute to promotion of program or policy?	107	50
(b) essentially routine and uninteresting?	83	65
(c) an undue burden on your time or interference with major interests?	42	101

The above listed answers have been tabulated by section groups and are available to anyone who will write the Chairman of the Committee. The comments associated with these questions have not been classified or recorded.

Part III of Questionnaire on Comparison of Earnings and Hours Worked

Considerable attention was given to the preparing of questions on the subject of earnings and hours worked that would be clear to everyone. We found that our hopes were not fully realized. It was desired to have comparisons on the annual basis. Estimates and interpretations had to be made on some replies.

The results for 230 teachers are tabulated by section groups in Table III–A. A few observations are as follows:

Last Year of Teaching

Average annual salary for teaching: $5800
Number with extra income:
Urban 113 or 85%
Non-Urban 71 or 74%
Average total annual salary: $7650

First Year in Industry

Average annual salary: $ 9800
Number with extra income: 57 or 25%
Average total annual salary: $10,100
% increase of first year in industry over last year of teaching: 32%

TABLE III–A

LAST YEAR OF TEACHING

ASEE Section Group	No. of Teachers	Annual Salary for Teaching (Dollars)			No. with Extra Income	Extra Income (Dollars)			Total (Dollars)		
		Min.	Max.	Aver.		Min.	Max.	Aver.	Min.	Max.	Aver.
A-U	32	3600	10,000	5850	27—84%	500	7000	2100	4800	14,000	7950
A-N	13	3900	7000	5200	11—84	500	10,000	2050	4000	17,000	7250
B-U	22	3950	9000	5700	21—95	1000	9000	2500	5250	18,000	8200
B-N	14	3800	7000	5100	10—71	600	3700	1200	3800	10,300	6300
C-U	32	3600	9600	5300	26—81	200	4100	1450	3600	11,400	6750
C-N	20	3600	10,350	5450	16—80	225	5000	1400	3600	10,900	6850
D-U	33	4200	10,000	6600	26—79	600	18,000	2900	4200	28,000	9500
D-N	22	4000	9500	6200	14—64	250	3600	1200	4000	12,300	7400
E-U	6	4500	7500	6050	5—83	100	2000	1050	6200	7,700	7100
E-N	18	3600	12,500	6950	14—80	100	4000	1150	3600	12,500	8100
F-U	9	4700	7000	5550	8—90	200	8000	2300	4900	15,000	7850
F-N	9	5400	8200	6400	6—67	150	3800	1350	6000	12,000	7750
	230			$5800	184—80%						$7650

Extra Income: Average for entire group of 230—$1850.
Average for 184 reporting—$2300.

FIRST YEAR IN INDUSTRY

ASEE Section Group	Annual Salary (Dollars)			No. with Extra Income	Extra Income (Dollars)			Total (Dollars)			% Increase Total Average
	Min.	Max.	Aver.		Min.	Max.	Aver.	Min.	Max.	Aver.	
A-U	2600	19,000	10,000	7	500	3500	250	2600	19,000	11,050	39
A-N	4500	20,000	8,800	3	50	4000	400	4500	24,000	9,200	27
B-U	4800	18,000	9,700	8	300	3000	500	4800	18,000	10,200	24
B-N	5400	12,000	8,300	2	1000	1100	150	6000	12,000	8,450	33
C-U	4900	15,000	8,800	5	300	3000	200	4900	15,000	9,000	33
C-N	4200	14,000	8,700	5	450	3000	400	6300	16,000	9,100	33
D-U	6000	36,000	10,400	8	200	3000	350	6000	36,000	10,750	13
D-N	5300	18,000	10,300	7	250	2700	400	5300	18,000	10,700	44
E-U	6700	14,000	9,750	0				6700	14,000	9,750	37
E-N	5500	20,000	9,800	3	1000	4800	500	5500	20,000	10,300	48
F-U	7400	12,000	9,800	3	200	2850	500	7400	12,500	10,300	30
F-N	7200	25,000	12,150	6	150	2600	700	7200	26,700	12,850	65
			$9,800	57—25%						$10,100	32%

Extra Income: Average for entire group of 230—$300.
Average for 57 reporting—$1400.

TABLE III–B

(A) Unfavorable comment on teaching load on account of:	Comments indicated that teacher considered his work load as:												Total
	Heavy						Excessive or burdensome						
	A	B	C	D	E	F	A	B	C	D	E	F	
No reason given		5		4	2	5	1				2		19
Teaching class-hours (including evening classes)	3	2	6				1	2	6				20
Need for consulting or other work to supplement income	2	2		3		3	1		4	1			16
Preparation time, grading papers	3	2	1	1		1		5	2				15
Administrative assignments	2	2	1	3	2	1			2				13
Research	1			4		1		1	1				8
Teaching and supervising graduate students doing research	1	1		1		2		1	1				7
Inadequate staff	3	1	1						1				6
Laboratory	2				1		1		1				5
Own graduate study program	2	2											4
Miscellaneous					3	2		1					6

(B) Work load in comparison with industry considered:	A	B	C	D	E	F	Total
About the same	4	3		15	3	2	27
Lighter	3	5	6	15	2		31
Not excessive	4		4	4	2	4	18
Reasonable	5	3	7	4	2		21
No concern about the number of hours	5	1	5		1	1	13
No comment	10	6	9	2	7	2	36

The comments on work-load as a part of III on Comparison of Earnings and Hours worked were considered significant and are summarized in Table III–B.

Part III of Questionnaire Summarizing Comments on Work Load

It is gratifying to know there are a few rugged individualists left among us. A half dozen gave a response to the effect that fringe benefits were of little importance to them and one said, "I believe that my own best security rests in me and my abilities."

The obvious conclusion from the response to this question, is that industry is considered in the lead on retiremment, insurances, and travel allowances, and

TABLE IV (Questionnaire–Part IV)

Response to question on Fringe Benefits, which read as follows:

"Fringe benefits have an overall effect on your economic status; e.g., retirement benefits, insurances, pay for absence, vacation time, travel allowances, etc.: Indicate one or more on which you place the greatest value and state which position provides the greater benefit."

	No Difference							Education Better							Industry Better						
	A	B	C	D	E	F	Total	A	B	C	D	E	F	Total	A	B	C	D	E	F	Total
No comment	4	5	5	7			21														
Retirement	6	5	5	16	3	1	36	3	5	2	4	2	2	18	9	11	24	18	15	8	85
Insurance	4	5	3	15	5	1	33	6	2	2	1			11	9	14	19	32	13	4	91
Pay for absence	5	3	4	12	4		28	3	1	8	2	1		15	1	6	5	13		2	27
Vacation	3	9	4	9	3	1	29	23	2		20	5	5	55	1	4	2	13	4	1	25
Travel allowance	3	1	3	8	3		18	4			1			5	11	12	10	34	11	5	83
All other factors								2				2		4	4	1	2	2	3	3	15

that education provides the better vacation attractions, at least time-wise. A few comments were to the effect that education provides "no paid vacations."

Rate of Advancement (Questionnaire—Part V)

The following question was asked regarding rate of advancement:

V. "How does the rate of advancement you expect (or have experienced) in industry compare with what you expected for yourself in teaching?
   A. With respect to earnings?——
   B. With respect to standing among your associates and in your community?" ——————

A few comments:

(1) "An industrious person moves ahead anywhere."
(2) "People in a college town might have a little more respect (or is it pity) for the teacher."
(3) "Small resentment against teachers among industry people."
(4) "Standing no concern."
(5) "Standing in the community, education is better, while with associates industry is better or little difference."

The answers to this question undoubtedly indicate that industry is able to advance the engineer at a faster rate so far as earnings are concerned. A number of the teachers had several years' experience at the time their answers were given and were quite enthusiastic about their improved status and outlook for the future.

From the appraisals of the engineer's position so far as his relations to community and associates are concerned, one might conclude that working in industry is also somewhat more attractive.

Reasons for Leaving Teaching Position (Questionnaire—Part VI)

While it would have been much easier to analyze a questionnaire that listed a number of reasons for the respondent to check off, the Committee preferred to state this question in such a way that no answer would be suggested. It appeared as follows:

> *Reasons for leaving teaching position*—State in your words, using a short phrase, the reason that primarily motivated you to move. If more than one, state second in importance and third in importance.

Without some attempt to classify the answers there would be a long list. The following groupings are believed to represent the reasons, with some interpretation on the part of the members of the Committee who read and analyzed the questionnaires.

Reasons pertaining to

(a) Personal, family, environmental, health, geography, or climate factors.
(b) Lack of recognition or appreciation by the college, community, or society.
(c) Relations with college and administration, and to disagreement with policies of various kinds.

TABLE V (Questionnaire—Part V)

	A	B	C	D	E	F	Total
No comment	1	2	1	5	1	1	11
(A) Earnings							
No difference	3	1	2	6	3	2	17
Education better	2	1	0	1	1	0	5
Industry better	40	37	38	46	20	17	198
(B) Standing							
No difference	15	17	15	23	5	8	83
Education better	9	6	11	2	10	3	41
Industry better	16	13	12	25	9	6	81

TABLE VI (Questionnaire—Part VI)

	Total Number of Teachers	(a)			(b)			(c)			(d)			(e)			(f-1)			(f-2)		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
A-U	13	1	2	0	0	2	1	5	9	2	7	4	1	3	2	0	12	8	1	6	1	2
A-N	32	2	1	0	0	1	0	1	1	0	0	2	2	4	1	0	4	1	1	2	1	0
B-U	14	1	0	0	0	0	0	3	7	5	2	3	3	4	2	0	14	2	0	1	1	3
B-N	20	1	0	0	0	0	0	6	1	0	0	2	1	1	0	1	8	5	0	1	1	2
C-U	20	2	2	2	0	3	2	3	3	4	0	5	0	2	5	1	21	5	6	4	4	2
C-N	33	0	1	1	2	0	0	3	4	4	1	2	1	5	2	0	11	3	1	0	2	0
D-U	22	4	0	1	1	1	1	6	7	5	2	7	3	7	1	1	15	5	4	4	3	1
D-N	33	1	2	1	0	0	1	5	5	4	2	1	0	5	3	1	7	4	2	2	0	0
E-U	18	0	0	2	0	0	0	0	1	1	1	0	0	2	5	0	4	2	0	0	1	1
E-N	6	2	0	1	0	0	1	2	7	1	1	3	0	3	2	1	8	2	2	5	2	0
F-U	9	1	0	1	0	0	0	2	3	1	1	0	1	2	1	1	4	2	0	1	3	0
F-N	10	0	1	0	0	0	0	0	3	3	2	0	1	0	2	1	8	1	0	0	0	2
Totals	235	15	9	9	3	7	6	36	51	30	19	29	13	38	26	7	116	40	17	26	19	13

TABLE VII (Questionnaire—Part VII)

Classification of statements of advantages of industrial employment:	Number of times that reference was made to statement:						
	A	B	C	D	E	F	Total
Salary or other dollar values including travel allowances; 12 months employment	35	25	37	36	22	17	172
Challenge of new job with growth potential and opportunity for advancement	15	9	19	6	9	3	61
Industrial work varied, creative, dignified, practical or interesting; "I am a part of progress."	0	7	8	13	4	9	41
Working with competent and stimulating professional people under competitive conditions in good professional and business atmosphere	10	8	1	7	1	1	28
Less time on job; less pressure; more satisfied with amount of work	6	3	10	7	1	0	27
Freedom of action; opportunity to be own boss	4	5	3	7	6	1	26
Good facilities and working conditions	1	4	3	8	3	5	24
Recognition by supervisors for good work; respect for opinion and efforts; rewarded on merit	0	3	0	12	0	3	18
Professional recognition and personal development	8	2	3	0	0	0	13
Attraction of stimulating research	4	1	3	5	0	0	13
Increased and clearly expressed responsibility, authority, and accountability	3	3	0	4	1	1	12
No advantage except money	0	1	3	0	1	0	5
Miscellaneous	1	2	5	7	0	1	16
						(Total)	456

(d) Dissatisfactions about the work, the work load, and facilities on the campus.
(e) Desire or need to get new experience, to have more challenging or interesting work.
(f) Security: (1) Income and fringe benefits.
(2) No permanent position available; no tenure or no opportunity for advancement.

Table VI summarizes the results as they were analyzed according to the above listed factors. 1–2–3 at the heads of the column indicates the order of importance as stated by the respondents. The six section groups are shown for both Urban (U) and Non-Urban (N) schools.

The three columns under (f-1) Table VI relating to income show the most frequent responses. There were 253 subjects mentioned as "reason #1"; of these 116 or 46% relate to income. While the dollar sign seems to be the most significant single factor in this problem, the importance of the remaining factors should not be underestimated by administrators and the engineering profession generally.

Advantages of Industrial Employment (Questionnaire—Part VII)

The questionnaire included a request to "Name two features of present employment that impress you as being most advantageous, as compared with teaching."

The results as analyzed are summarized in Table VII. "Salary or other dollar values" make up 172 out of 456 references or 37%. Some favorable reference to the work and working conditions accounts for approximately 50% of the replies.

Advantages of Teaching (Questionnaire—Part VIII)

The questionnaire (Part VIII) similarly included a request to "Name two features of teaching that impress you as being most advantageous as compared with industry."

The results as analyzed are summarized in Table VIII.

Satisfactions of teaching and the feeling that one is doing something of value to the society he serves seem to stand out

TABLE VIII (Questionnaire—Part VIII)

Classification of statements of advantages of teaching.	Number of times that reference was made to statement:						
	A	B	C	D	E	F	Total
Teaching and relationships with students; satisfaction of accomplishment; opportunity to serve	26	20	25	24	10	7	112
Personal freedom to think; explore; to select areas of work and research	18	14	17	29	5	5	88
Time freedom; flexible working hours; vacations	13	10	13	22	3	10	71
Academic environment and atmosphere; working with high level of professional associates	13	5	11	19	12	10	70
Less pressure or competition	4	6	6	10	5	4	35
Opportunity to study for professional growth and advancement	10	4	9	3	5	2	33
Feeling of security and stability	1	1	2	6	2	0	12
Prestige	0	4	0	1	2	0	7
Higher level work	2	0	1	0	1	1	5
Miscellaneous	1	0	3	4	0	0	8
						(Total)	441

as the primary attractions of the profession. Academic freedoms and time freedoms as well as the environment of the campus also rank high.

Improvements (Questionnaire—Part IX)

Next, the questionnaire included the following opportunity to make recommendations:

IX. "If you had the authority to make improvements in the general area of attracting and developing effective and dedicated engineering teachers, what would you do?"————————————————————

Here, as might be expected, providing adequate compensations shows up more frequently than any other one suggestion. This includes improvements in fringe benefits of various kinds: parking facilities, faculty clubs, gymnasium privileges, university loans at low interest, and exemption from paying tuition for graduate study. A frequent comment related to the importance of 12 months of income with the annual salary comparing favorably with that of industry. Providing sabbatical leaves and encouraging professional activities away from the campus by paying travel and expenses also seem important fringe benefits.

The following rather long list of recommendations is made without reference to frequency. They are classified as pertaining to staff, curriculum, facilities, young engineers in teaching profession, industry and professional relations, and administration. It will be noted that a number of them might appear in more than one classification.

General Recommendations Pertaining to—

Staff—

Provide adequate staff to permit reasonable teaching load allowing time for study, research, and thesis supervision.

Promote on merit, recognizing the importance of scholarship, good teaching and research; make salary and promotion dependent on effectiveness of teaching if teaching is a primary duty; make teaching as remunerative as research.

Make awards for teaching as good as for publication activities; weed out the incompetent and those who have not kept pace in their fields; arrange for "early retirement."

Beware of or eliminate tenure; tenure has bad as well as good points; loss of incentive and failure to grow with the profession.

In contrast: Provide longer term appointments.

Build careers at "one" university; reduce the growing tendency to seek opportunity by moving from one school to another.

Curriculum—

Improve curriculum.

Reorganize courses to promote "thinking."

Coordinate laboratory with class room work so that experiments have a real function in the teaching process.

Facilities—

Provide adequate laboratory and teaching facilities. Furnish teaching aids as freely as research equipment.

Provide adequate clerical and other assistance to relieve teacher of routines, paper work, grading problems, and other non-teaching duties; reduce red tape.

Provide facilities and opportunities for research and creativity (including independent research).

Increase load-factor by using engineers from industry for evening classes.

Teaching Methods—

Develop improved teaching methods.

Learn from experience of armed forces schools in their use of teaching methods.

"Can" standard engineering lectures, using best talent available, permit students to review the filmed lectures as many times as they wish.

Give tests frequently, taken randomly from a large number of standard quizzes.

Make answers available to all homework.

Young Engineers in Teaching Profession—

Promote teaching as a profession among graduate students but set an exacting criterion on both pedagogical and technical ability of prospective teachers.

Provide fellowship opportunities with attractive pay.

Contract with graduate student for full pay on half normal work load while taking graduate work to be followed by as many years of full work load as the graduate work consumed.

Train new teachers and provide them with assistance on "how to teach"; use senior members of department to guide them during first year.

Require instruction in teaching methods.

Encourage young instructors to develop their own courses.

Permit choice of subjects by teacher.

Allow and encourage auditing technical and non-technical courses.

Impress upon young teacher his responsibilities to his students.

Inform young teachers of policies and requirements relating to tenure, promotions, and opportunities in the profession and institution.

Place less emphasis on doctor's degrees and research; remove Ph.D. barrier to advancement; recognize practical knowledge.

Provide assistance with expenses to attend short courses.

Pay travel costs to new job.

Industry and Professional Relations—

Encourage relationships with and require experience in industry; provide summer employment opportunities; encourage consulting.

Promote a two-way flow between industry and education.

Use practicing engineers for part-time teaching.

Appoint a committee of competent, interested, and successful engineers from education and industry with broad administrative and budgeting power to operate each institution.

Recognize professional society affiliations and activities; pay expenses to participate or attend meetings.

Require one semester every five years in practice; or two years every ten.

Administration Primarily—

Take a look at college organization and revise or reorganize for improved efficiencies, personnel relations, and public relations.

Appoint competent administrators and do not mix teaching and administration.

In contrast: Reduce administrative load on department hands, so that they can devote full time to teaching.

Appoint more competent young men to responsible administrative positions.

Provide administrative supervision over research and consulting.

Do not separate teaching and research staff; make allowances in teaching schedules so that research is not over-time.

In contrast: Do separate teaching and research staff.

Have two types of faculty: teaching and research.

Balance staff with both practical and research men.

Get a few outstanding men on staff.

Provide opportunity for teachers to have a voice in policies and responsibility for curriculum and program planning, and encourage teachers to take a more active interest in the administration and operation of the institution.

Require deans and department heads to have five years of engineering experience.

Establish or revise goals and objectives and reduce resistance to change when necessary.

Establish standards of performance and responsibility, and eliminate false teacher standards.

Improve intellectual and research atmosphere so that it is challenging and inviting.

Establish greater respect and prestige for engineering teachers' professional and social status.

Develop methods and take time to accurately measure the quality and effectiveness of teaching.

Raise standards of secondary schools and engineering colleges; up-grade entrance requirements; lowered standards

have a disastrous effect upon the teachers' morale and standards.

In Retrospect (Questionnaire—Part X)

A real test of whether a decision was a good one is: if you had to do over again, would you make the same decision.

Part X of the questionnaire, stated as follows, provided this test:

"If you were back at your previous position facing the same situation again but had the benefit of the experience on your new position, would you make the decision to resign?"

Of those who answered, 211 said *yes* and 14 *no*. The comments most frequently related to need for more money and desire for experience.

Looking Ahead (Questionnaire—XI)

The survey closes on a much more encouraging note, if one wishes to interpret it that way, by the answers to the question: "Do you dream or plan to someday return to the campus?"

As a teacher:	Yes *148*	No *51*
Into administration:	Yes *47*	No *76*

By the time the questionnaires were filled out, a number indicated they had already returned or were planning to return soon.

A typical comment made at this point read as follows:

"I fully intend to return to teaching someday after I have gained considerable practical experience or after my sons and daughters are through college and I can afford to return."

In Conclusion

Another report could be written on comments scattered throughout the questionaires. Many of them contain helpful suggestions. Many are criticisms of a nature that indicate dissatisfactions that might be associated with improper placement. Thus, one might conclude that the people who have left teaching belong in one of two categories:

(a) Those who have a real need for more income.
(b) Those who are not fitted for teaching and who will be more successful and happy in other employment.

However, a large number of ex-teachers express dissatisfactions, whether real or imaginary, that should not be overlooked in appraising the various factors of the problem of recruiting and developing qualified teaching personnel. A comment from one ex-teacher puts into a few words what might very well serve to spotlight the overall problem:

> "Present emphasis on salaries is entirely correct. But I do not believe that money is the main reason for teachers leaving. Other factors are usually of more importance."

If this is a true statement, engineering education must endeavor not only to improve the salary situation, but it should also learn more about what the other factors are in each local situation and what to do to correct them.

GLENNAN TAU BETA PI LECTURER

T. Keith Glennan, administrator of the National Aeronautics and Space Administration and President-on-leave of Case Institute of Technology, will deliver the first annual Tau Beta Pi lecture at the American Association for the Advancement of Science meeting in Chicago in December 1959. Dr. Glennan's subject will be "A New Order of Technological Challenge in the Nation's Space Program."

The Tau Beta Pi Association, national engineering honor society and an affiliate of the A.A.A.S., plans to sponsor a major address at each annual meeting of the A.A.A.S. Dr. Glennan's lecture will be given in the Grand Ballroom of the Hotel Morrison, Chicago, on Sunday evening, December 27, 1959, at 8:00 P.M.

Utilization of Engineering Faculty Time

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The Hazen report published in the May, 1958, edition of the JOURNAL is the latest of a number of studies, investigations, and predictions of the hordes of engineering students who, it is supposed, will descend upon educational institutions in the years immediately ahead. There is no need to review the figures or the bases for arriving at them. In general, the facts are clear: if history repeats itself in regard to the proportion of high school graduates who seek a college education and the proportion of college students desirous of studying engineering, then schools of engineering are going to have their hands full, beginning about 1960.

This upsurge of students will present many problems to engineering schools, but the one of most concern to us at present is the shortage of faculty. This aspect of the overall problem has received considerable attention, both in the pages of the JOURNAL and elsewhere. In many of these writings the solution most often offered is that of a substantial increase in faculty salaries. It is reasonable to assume that this would indeed do much to minimize or possibly eliminate the problem of recruiting and retaining adequate teachers. On the other hand, for most schools, such a solution hardly seems feasible in the immediate future, so administrators must also examine other possibilities.

The most obvious possibility is to make better use of whatever faculty members we do have. Some schools are devoting time and money to experimentation in ways to permit coverage of faculty members over a greater number of students. Closed circuit television offers promise along this line as does more use of assistants of one kind or another. Efforts to explore these and other means of improving faculty utilization should be continued. Would it not be appropriate, however, to also raise some questions as to how individual faculty members make use of their time?

To question how a faculty member makes use of his time may "not be done" in most academic circles, but if we are genuinely concerned about this expected increase in the number of students and the resulting need for better utilization of faculty, why should this subject be untouchable? As individual faculty members, are we not personally interested in making the best use of our time? As administrators, are we not interested in having our faculty as a whole make the most constructive use of their time? Is it conceivable, perhaps, that if we knew the facts, faculty assignments involving courses, committees, and general administrative duties could be rearranged so that faculty members spend a greater proportion of their work week on constructive activities and less on "busy" work?

Although department heads do attempt to balance work loads, there seems to be a lack of information as to how much time is actually consumed in typical faculty activities. Most assignment decisions must be based on assumptions, past practice, or intuition. In an effort to discover how faculty members do actually spend their time, a study was recently made of one engineering department for this purpose. To be exact, the study revealed how faculty members spent their time during the specific period of observation which was one complete academic semester. This study was made, not for the advantage of the department head in this case, but to illustrate the type of information that

could be obtained and the method that could be feasible in undertaking such a study.

The Study Design

The method employed in this study was that of work sampling. The basic theory and details of this method are probably well enough known that little or no explanation is needed here. You are reminded that the method is a statistical one making use of a large number of random observations of the activity under study. If the observations are made purely at random it is possible to make some definite and meaningful statements regarding the results obtained. This method of studying human activity is fairly common in factories, but its application in this case to an engineering faculty is believed to be unique. Naturally, certain problems were encountered.

Perhaps the main problem was the threat of interference with academic freedom. This was minimized in two ways. First, the nature and purpose of the study were carefully and thoroughly explained to each cooperating staff member in advance of the study, and his wholehearted cooperation thereby secured. Secondly, it was guaranteed that all information on individual performance would be kept completely confidential and no one other than the analyst would ever have access to it. This latter point has been scrupulously maintained. Summary data for the entire study were given to all participating staff including the head of the department, but no data on individual performance was or will be released.

The basic design of the study took into account the fact that academic positions seldom have time requirements imposed on them except for the periods when classes meet. It was understood that any attempt to learn how an instructor spends his time must allow for the fact that he is free to grade papers at midnight at home if he prefers this to grading them in his office during the day. Although the basic factor in the sampling design was time, the week was divided into two parts and slightly different designs were developed for each. The first part was composed of the hours during the week when classes meet and when offices are usually open. In this case these hours were 8–12, Monday through Saturday, and 1–5, Monday through Friday, for a total of 44 hours. The second part was simply the rest of the week including Saturdays and Sundays.

The design for sampling activities both "during class hours" and "after class hours" made use of the principle of random observations mentioned earlier. For the "during class hours" four ten-minute intervals were selected at random each day. Each cooperating staff member was contacted during that ten-minute period and a notation was made as to the type activity he was engaged in at the moment of observation. There were 20 cooperating staff people, and the study lasted for an entire 16 week semester. The theroetical number of observations was 6,600; however, of that total 29 were lost, which yielded 6,571 actual observations for this portion of the study.

For the "after class hours" portion of the study, 20 days during the semester were selected at random for each of the 20 staff members. For each of these 20 days the staff member gave a full report of his activities *after* class hours that dealt with his job. He did not, however, know ahead of time on which days he would be queried. This report was in the form of units of time spent on one or more various categories of activities already established. In the "during class hours" section, the observations were instantaneous and the total amount of time spent on any one type of activity was obtained by multiplying the per cent of observations made of that activity by the base work week of 44 hours.

Activity Categories

In determining the categories of activities, it was reasoned that the myriad of different acts performed by all instructors actually fall into five basic groups, namely, teaching, research, administration, miscellaneous, and personal activity. Each activity observed was therefore noted under one of the above five categories. A number of subheadings, however, were used in order to more clearly

FIG. 1. Activity proportions for entire department

	Observed Percentages		Confidence Intervals
Teaching	41.9		40.7–43.1
In Class		26.4	
Course Preparation		8.2	
Course Follow-up (alone)		4.5	
Course Follow-up (with others)		2.7	
Research	4.0		3.5– 4.5
Individual		.8	
Group Discussion		1.3	
Experimental		1.9	
Administration	16.0		15.1–16.9
General (alone)		6.1	
Group Discussion		4.3	
Supervision		1.0	
Meetings (formal)		2.8	
Student Counseling		1.8	
Miscellaneous	20.4		19.4–21.4
Off Campus Visitors		3.3	
Meeting Off Campus		2.0	
Consulting		2.4	
Plant Visitation		.6	
Personal Development		12.0	
Personal Activity	17.7		16.8–18.6
	100.0	100.0	

describe the activity and to give more detail concerning the way in which engineering staff members do spend their time. These subheadings are listed in Figure 1.

Although these subheadings are presented here with no detailed explanation of their meanings, it must be kept in mind that during the actual study they were given exact meanings and rules were established to determine whether an observation should be noted under one subheading or another. It should also be noted that for the purpose of the study, the observer was not interested in learning whether the subject was engaged in reading, writing, walking, or any other physical activity. His interest was in noting the *purpose* of the subject's activity, as for example, whether or not such reading was connected with a research project, the preparation of material for class presentation, or personal relaxation.

The Findings—During Class Hours

The application of the sampling and observation designs as described above resulted in a great deal of data which are interesting from the points of view of individual subjects as well as of department heads. Below are presented enough of this data to indicate the overall results.

In considering first the results of the "during school hours" portion of the study let us recall that the time period used as a base is the 44-hour week. Analysis of the data shows that the particular staff under study divided their time during the semester as follows:

Teaching	41.9%
Research	4.0%
Administration	16.0%
Miscellaneous	20.4%
Personal Activity	17.7%

Thus we mean that, on the average during the semester studied, the staff of this engineering department spent 41.9% of the basic 44-hour week on duties connected with teaching classes, 4% of this time in research, 16% of this time in administrative work, 20.4% of this time in miscellaneous work connected with their jobs, and 17.7% of this time in personal activity.

This information is presented in greater detail in Figure 1. The per cent totals for each of the main categories are broken down into per cents for each of the subheadings. A word of explanation should be given concerning the relatively low figure (4%) shown for research. This particular category was difficult to define since research itself is difficult to define. After much thought it was finally decided, for purpose of the study, to consider time spent on *assigned* research projects, only, as falling into the "research" category, and to consider time spent on private research, such as preparation of a journal article, as falling under the category of "personal development."

The column headed "Confidence Intervals" in Figure 1 may perhaps also need a word of explanation. These confidence intervals have been computed at the 95% confidence level and are useful

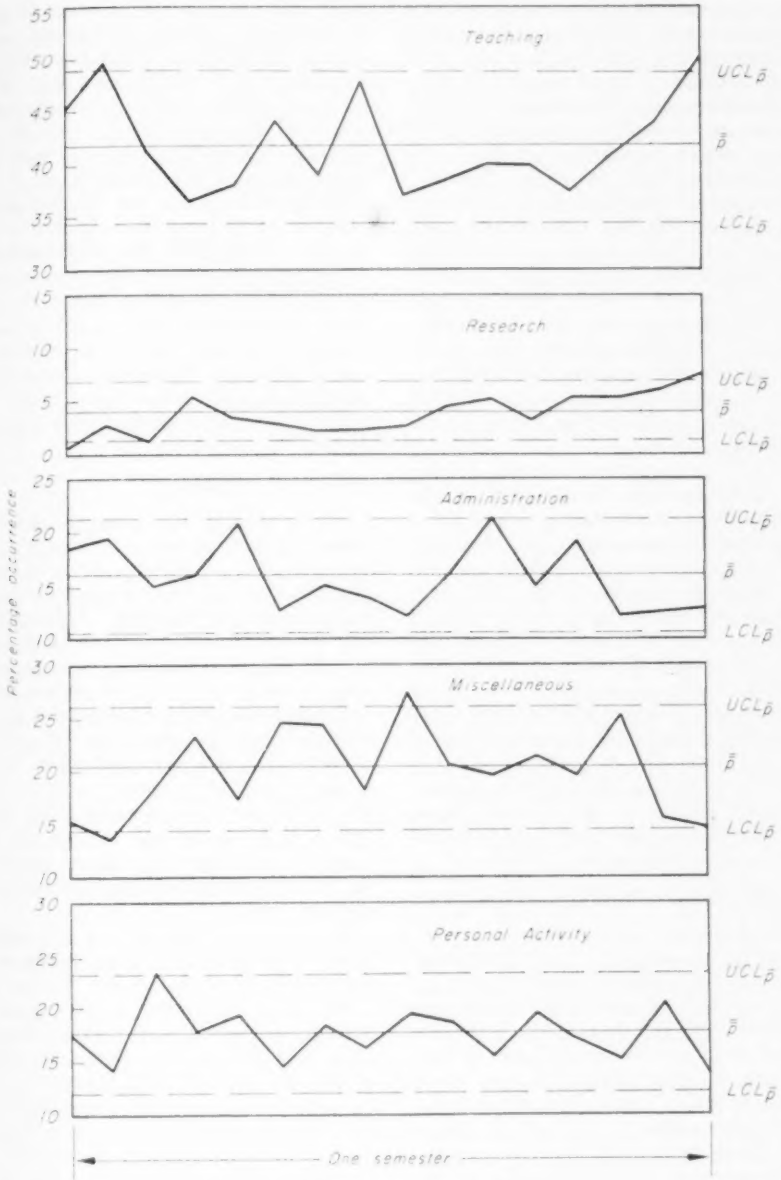

FIG. 2. Control Charts.

in appraising the accuracy of the observed percentages. Consider, for example, the category of teaching. The best point estimate possible of the percentage of time the staff as a whole spent on activities connected directly with teaching is 41.9%. We cannot be certain that this is correct; however, we can be 95%

confident that the true percentage of time spent on teaching activities is some place between 40.9% and 43.1% as shown in the confidence interval column.

The percentages mentioned so far are for the entire semester; however it might be of interest to examine the data as it breaks down week by week. Figure 2 shows information in control chart form for each of the five activity categories. From these charts is gained a picture of the stability or consistency of performance of the staff week by week throughout the semester. The solid lines in the center of the charts correspond to the overall semester averages, and the dotted lines represent the three sigma control limits as typically used in statistical control work.

Since the percentages plotted are for the entire group in the study, it is difficult to draw conclusions from the series of control charts in Figure 2. However, in looking at the teaching chart one can see peaks in activity at the beginning, middle, and end of the semester, and can postulate that these occurred during the pressure periods of getting courses underway, mid-term exams, and final exams and grades. The research control chart seems to indicate that those assigned to research were slow in getting underway on these projects and had to spend a considerable portion of their time on them near the end of the semester in order to meet completion deadlines.

The Findings—After Class Hours

As mentioned earlier, the sampling design for after-class-hours activity was less exacting and depended upon the memory of the subject rather than on outside observation. Nonetheless, it was felt necessary to obtain some measure of the amount of time staff members were spending on university business outside of regular office hours. This figure turned out to be 10.8 hours per week for the average staff member in the department studied.

By referring back to the during-class-hours section of the study and subtracting the personal activity observations from the basic 44-hour week, we obtain a figure which represented the amount of time the average staff member devoted to university business during the basic week. This figure is 36.3 hours which, if added to the other figure, 10.8, yields the sum of 47.1 hours. This represents the total time spent each week, on the average, by staff members in that department on university business. The total figure is the only one of significance, since as we all know, there is no time requirement imposed on a staff member, other than meeting classes, as to *when* he should do his work. This aspect of academic freedom needs no defense, and this study, at least, shows that engineering teachers do perform a considerable portion of their work (over 20%) at times other than normal university office hours.

Perceived Activity

Twice during the semester the cooperating staff members were asked to estimate the percentage of time they thought they were spending on the various categories of activities. This inquiry was made in an attempt to find out how closely self-perceived activity compares with observed activity. In general, this correlation was only fair—not that it could be expected to be otherwise. The most accurate estimates were made of the time spent in classes. Estimated average was 28.4% whereas the observed value was 26.4%. No doubt this degree of accuracy was achieved by simply computing class hour percentages of the basic 44-hour week.

The least accurate estimates were made of the amount of time spent in personal activity during class hours. The average observed value was 17.7%; yet the average personal estimate was only 4.2%. From this it seems obvious that the staff in general spent considerably more time on personal activity during the 44-hour week than they thought they did. Without exception the faculty estimated their time spent on personal activity to be much less than the percentage actually observed. The most accurate estimate made by an individual was three percentage points lower than the observed value of 20%. There were ten persons who estimated their percentages in this cate-

gory to be 0, 1, or 2, apparently with the belief that every moment of their time was constructively spent or that any time they did waste was negligible. It is interesting that the actual observed time in this category averaged 17% for these ten persons, which is very close to the average of 17.7% for the entire group of 20.

Usefulness of the Findings

This study was experimental in nature and dealt not only with the question of how engineering faculties spend their time but also with the feasibility of using the work sampling technique to measure faculty activity. For this reason it is impossible to report any really useful purpose to which the results were put. So much emphasis was placed on the avoidance of violating academic freedom and the maintenance of secrecy that even the head of the department can make little use of the findings. Therefore if we assume that such a study is to be made for a practical purpose we can only speculate on its possible value.

Data such as presented in this paper have significance only in relation to comparative data from other sources, and unfortunately, no such similar data is available. Thus it is impossible to describe these percentages as high, low, or average. These data were secured by studying the full time faculty of one engineering department for one semester. Therefore, to the extent that this particular semester was typical of all semesters of activity for the faculty of this particular department, the results can be said to be typical. To the extent that this department is representative of all engineering departments, the results can be said to be representative. All we can say with certainty is that the data represent a start in the direction of learning more about the time requirements of activities engaged in by engineering faculties.

It would seem that the practical benefit of a study such as this lies in the area of educational administration. If such a study is undertaken, however, care must be taken to guard against measuring the worth of accomplishment in terms of time spent on achieving that accomplishment. For example, although Professor A spends less time in preparation of a lecture than Professor B, his lecture may be infinitely better. More time in preparation may be needed by some professors than by others, due to differences in their backgrounds and whether or not they have taught the course before, as well as many other factors. Since the technique of this study measures time only, a large enough sample must be taken that many of these differences average out.

Perhaps the most valuable information gained from a study of this kind is discovering how much time faculty members spend on activities that can and should be performed by clerical, graduate assistant, or other types of personnel. Since secretaries are more plentiful and cost less than fully qualified engineering professors, it makes both economic and academic sense to be certain that engineering professors spend their working time on services only they can perform. This is better faculty utilization in the true sense.

In deciding a faculty member's total assignment, a department head considers a host of questions. For example . . . how many courses constitute a full load? How much allowance must be made for teaching a course the first time, as compared to the fourth time? How to differentiate between undergraduate and graduate courses? How much time does a particular committee assignment require? How much time is needed for student counseling? Ad infinitum. Obviously these questions are answered somehow. In many instances, however, the answers appear to be based on some rule of thumb, or past practice, or other arbitrary standard.

If a sampling study were made, one could learn how much time is actually spent in counseling students, preparing lectures, grading papers, etc. Although the information would not be exact, its limits of accuracy would be known, and if the study were made a continuous one, accuracy would be improved in the long run.

Consequently, with time data for individual staff members, and with a sep-

arate appraisal of performance, a department head should be in a much better position to counsel and advise his staff. Since he already has his own opinion of the staff's member's quality of performance, with the time data he could make suggestions to his staff as to how their time could be spent more fruitfully—fruitful in the matter of promotions and salary increases. It is assumed that the matters of promotions and salary increases are of general interest to most staff members.

Is this too much interference with academic freedom? Perhaps. On the other hand, are engineering professors automatically immune from any attempt to improve their performance or to make better use of their time? Perhaps not.

It may be of interest to know, however, that a number of the persons who participated in this study regarded it as a welcome opportunity to improve their own performance. They expressed no particular concern with the reactions of the department head, but considered the findings of the study as information of value to them in improving their effectiveness and efficiency. In fact, two of the participants wanted the study to be a continuing one with the results being reported to them weekly so that they could use the information to guide and control their activities. They considered the data to be a measure of their success in achieving the best use of their time.

Final Statement

The author is fully aware that the material and ideas presented in this article are highly controversial in most academic circles. Although there is little question as to the soundness of the techniques used, there are many and varied questions concerning the application of these techniques in an educational situation. It seems appropriate, however, that engineers, who by nature and training constantly seek better ways to do most things, might devote some attention to a search for better ways to do their own jobs. In industry this is preferred practice; are engineering educators so different from practicing engineers?

It is not meant that the use of work sampling in administering engineering education departments be considered a panacea for the many problems to be faced in the years ahead. Neither is it the purpose of this paper to urge all department heads to find out how their staff are spending their time by means of a work sampling study. The results of the work sampling study are offered, however, as an example of effort devoted toward the solution of faculty utilization problems. Perhaps if we are more successful with efforts in this direction in general we need not campaign so strenuously for increased faculty salaries. Increases in salary might come as a well-earned reward!

AID FOR AUTHORS

Writing and Publishing Your Technical Book, a guide to the preparation of manuscripts of business, industrial, engineering, and professional books and how to arrange them for publication, has been made available upon request by the F. W. Dodge Corporation.

The 50-page paperback book explains the rudiments of planning a book, choosing a publisher, gaining the publisher's acceptance, and the standard provisions of the contract with the publisher. The aim of the book is "to provide a few guideposts in hitherto unexplored territory—the no-man's-land in which an author conceives the germ of an idea for a book, and then elaborates it into something concrete and promising enough to obtain the support and backing of a publisher."

Copies may be obtained from F. W. Dodge Corporation, 119 W. 40 St., New York 18, New York.

A Small Rocket for Laboratory Demonstration

A. R. DESCHERE

The Redstone Arsenal Research Division of Rohm & Haas Company acting as a research and development contractor for the Government in the field of solid propellants routinely tests a large number of solid propellant rocket motors. Because of safety considerations, these tests are conducted behind heavy barricades and data are recorded with complex electronic instruments; close and direct observation of the rocket motor and measuring instruments is not possible.

To permit demonstrations of basic principles of rocket propulsion to interested groups, a special rocket motor was built with instrumentation which could be observed directly. The set-up can also be used in college laboratories for experiments in reaction propulsion.

Gasoline and air were chosen as the fuel mixture because both have a relatively low cost, are readily available, and are relatively non-hazardous; most laboratories were assumed to have an adequate compressed air supply. The size of the rocket can be reduced if the air supply is limited or increased to provide a more dramatic exhibition, by using elementary scaling principles given, for example, in Chapters 3 and 7 of Sutton.[1]

[1] George P. Sutton, *Rocket Propulsion Elements*, John Wiley and Sons, Inc., New York (1956, 2nd Ed.).

The rocket motor consisted of a combustion chamber, nozzle, gasoline injector, and injector chamber for injection of air (Figs. 1 and 2). Gasoline was brought to the motor under pressure, and air was taken from a compressed air line capable of delivering 220 cubic feet per minute at 100 psig. Mild steel was used for the fabrication of the prototype which had a design safety factor of 60 with the motor body at 70° F. and an internal pressure of 100 psi; at a motor temperature of 1,000° F. the safety factor was reduced to 10 at 100 psi. For 347 stainless steel the safety factors would be about 60 at 70° F. and 30 at 1,600° F.

A schematic control panel (Fig. 3) was used to allow visual presentation of the operation of the system. Gauges on this panel indicated combustion chamber pressure, injector chamber pressure, gasoline flow rate, air line pressure, air flow rate, and rocket thrust. Temperature measurements in the motor and nozzle could be added if desired. Although the system was relatively safe the control panel was located in such a way that persons taking data would not be injured by any failure of the rocket motor.

Except for ignition, motor start-up was quite simple. The fuel and air flow at the expected motor chamber pressure

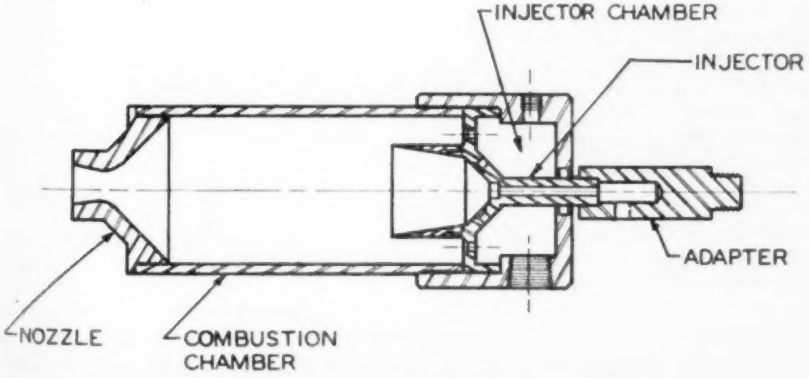

Fig. 1. Schematic diagram of gasoline-air rocket.

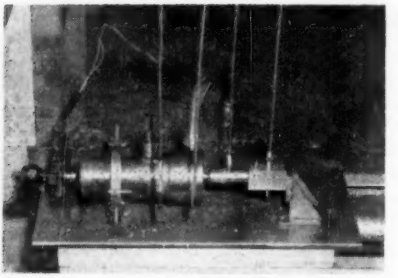

FIG. 2. Assembled prototype of gasoline-air rocket. Nozzle (at left) is partially blocked for adjustment of fuel and air-flow at the expected motor chamber pressure.

were adjusted by partially blocking the nozzle. The igniter (an electric squib) was then fired and if the fuel ignited the run was completed. However, ignition proved to be quite difficult. Spark plugs and hot wires were unsuccessful. An electric squib similar to those used in weapon systems gave ignition more than 50% of the time.

Because of temperature limits with a mild steel motor body, runs were held to 60 seconds or less. Use of stainless steel would allow longer runs. However, even a 60-second run was sufficient to allow the taking of enough data to completely characterize motor performance (Table

TABLE 1

DATA TAKEN DURING A SINGLE RUN OF THE GASOLINE-AIR ROCKET

Combustion Chamber Pressure P_c psig	Injector Chamber Pressure P_I psig	Air Supply Line Pressure P_∞ psig	Air Supply Line Temperature T_∞ °F	Pressure Drop Across Orifice in Air Supply Line P in. H_2O	Gasoline Supply Rate q_α cc/min	Atmospheric Pressure P_a psia	Gasoline Temperature T_g °F	Thrust F_t lbf
51.0	73.5	79.0	65.5	6.0	238	14.62	70.0	22.83

Nozzle, throat diameter, d_T = 0.670 in.
Nozzle, exit diameter, d_e = 0.780 in.

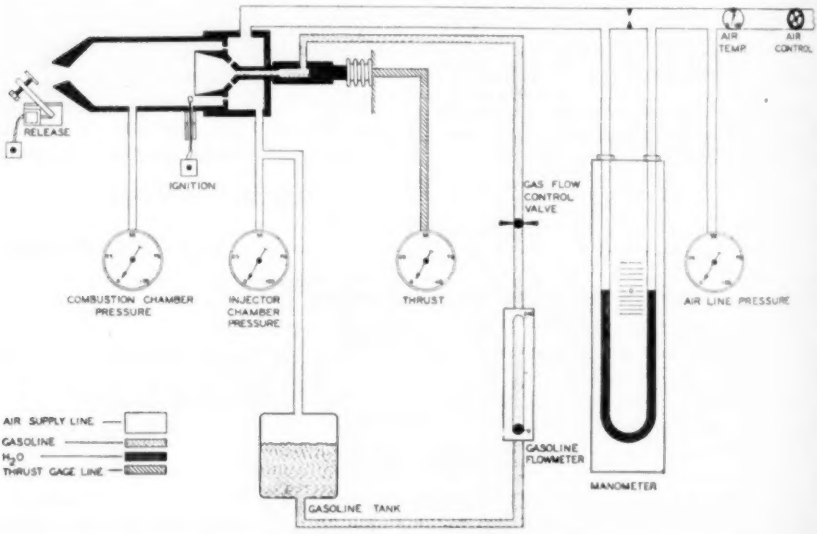

FIG. 3. Schematic control panel used to allow visual presentation of the gasoline-air rocket system.

TABLE II

DESIGN CONDITIONS OF GASOLINE-AIR ROCKET BASED ON 200% EXCESS AIR

Air supply pressure	100 psia
Injection chamber pressure	90 psia
Combustion chamber pressure	70 psia
Exit pressure	15 psia
Combustion chamber diameter (nominal)	3 in.
Combustion chamber length (nominal)	7 in.
Throat diameter	0.67 in.
Nozzle expansion ratio	1.36
Gasoline flow rate	0.006 lbm-sec^{-1}
Air flow rate	0.27 lbm-sec^{-1}
Combustion gas	
Temperature	1630° F.
Specific heat ratio	1.30
Specific gas constant	53.4 ft-lbf-lbm^{-1}-°R^{-1}
Exhaust velocity	3045 fps
Mass rate of discharge	0.28 lbm-sec^{-1}
Thrust	26.5 lbf
Specific thrust	95 lbf-sec-lbm^{-1}

I). Design conditions are shown in Table II.

A large number of experiments involving thermodynamics, fluid flow, heat transfer, and the chemistry of combustion are possible with this system. Variables can include fuel flow rate, air flow rate, fuel-to-air ratio, and combustion chamber operating pressure. Motor bodies can also be altered to vary the length, diameter, nozzle size, nozzle expansion ratio, and injector design.

Machine drawings, plans, and operating instructions will be sent promptly without charge to any college laboratory requesting them. Such requests should be addressed to Rohm & Haas Company, Redstone Arsenal Research Division, Huntsville, Alabama. Tentative arrangements have been made with an engineering firm to sell complete or partial units of this type to interested laboratories without royalty to Rohm & Haas Company.

Acknowledgments

The design, development, and experimental work on this unit were done by Mr. W. H. Groetzinger, Dr. J. E. Johnson, Mr. H. L. McGill, and Mr. C. A. Tidwell of this Division.

ENGINEERING TEACHERS' SALARIES RISING

The average professional income of engineering teachers in the United States has risen 8.3% since 1956, and their basic teaching salaries have increased 13.5% over the two-year period, according to a survey published for Engineers Joint Council. The survey covered more than 5,000 engineering teachers, or about half of the teachers in this field in the United States.

By the nature of their occupation, engineering teachers must do research and therefore earn more than their basic teaching salaries. Thus the average total professional income of engineering teachers, which was $8,862 in 1956, was $9,598 in 1958. The basic salary average rose by $894 per year, but there was a decline of 7% in outside income. Deans and department heads, however, showed an increase in both teaching and outside income. The total income of engineering teachers in public institutions rose more than the total income of those in privately supported institutions. Engineering teachers holding advanced degrees earned more.

The report entitled "Salaries and Income of Engineering Teachers, 1958" is the second detailed analysis of this group based upon data collected by the engineering income surveys of Engineers Joint Council. The first was conducted two years ago under the auspices of ASEE. The new report is published for Engineers Joint Council as a supplement to their recent report "Professional Income of Engineers—1958" and was prepared by the Bureau of Business and Economic Research at Northeastern University, Boston. Copies are available from Engineers Joint Council, 29 West 39 Street, New York 18, New York at 25 cents to cover handling cost.

. . . . . YET-ITUDES

To *All* Engineering Teachers

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What is the proper function of the Young Engineering Teachers and their committee? This is not intended as a rhetorical question. As the current chairman of the Committee for Young Engineering Teachers, I would like to ask every reader of this article what he thinks YET should accomplish. From the younger engineering teacher, I want suggestions on how YET can better serve him. What questions concerning his chosen profession are uppermost in his mind? How can the YET program help him resolve these questions? From the experienced teacher, I want comments and suggestions for programs for the YET. How can YET act as a catalyst to speed and make more effective the new teacher's introduction to the profession? From deans and other administrative officials, I would like comments on the proper role of YET at their institutions. How can the YET group act as a liaison between the administration and the newest members of their teaching staff?

In short, what is YET good for? This is not a new question—members of the Committee for Young Engineering Teachers have been exploring the answer since 1951 when the committee was established by the ASEE. Each year it is customary for the new chairman to review past activities of YET, and to point out areas of particular progress. Rather than repeat the excellent summary given by last year's chairman,[1] I would like to explore the future of YET, bringing in examples of particularly successful YET activities of the past year. My purpose is to stimulate comments and suggestions for improvement of the YET program from every engineering educator who reads this article.

The grass roots of YET are in its local groups at 135 engineering schools across the country. Each school has an Institutional Representative for YET chosen by the Dean of Engineering. Activities are coordinated by 12 Sectional Representatives who are members of the national Committee for Young Engineering Teachers (CYET). Also members of the national committee are the Secretary, who maintains contact with the Section Representatives, the Editor, the Program Chairman, the Vice-Chairman, and the Chairman. The committee members are scattered across the country, and business is conducted by mail. This inevitably leads to some slowness of action. Most of the committee members have never met each other. YET activities occur at three levels: institutional, sectional, and national.

Institutional Activities

Does your school have an active YET group? How does it contribute to the professional development of the young teacher? Programs vary greatly from school to school depending on local interests. A recent survey [2] showed a wide variety of YET activities, including conferences on teaching methods, luncheon and dinner meetings, bull sessions, in-

[1] Jerry G. Richter, JOURNAL, Vol. 49, p. 247 (December 1958).

[2] T. H. Rockwell, "The Impact of the YET Program at the Institutional Level," JOURNAL, Vol. 49, p. 678 (April 1959).

formal discussions with the Dean, picnics, and other social activities.

At the University of Illinois, the YET group has a luncheon meeting of the "Toastmaster" type, where each member has a chance to present a short talk. Other groups might adopt this idea, choosing the subjects of talks from those of particular concern to young engineering teachers. Noon meetings are relatively easy to schedule and conflict with few other activities. An active program at the University of Alabama centers around various social activities, often including the wives.

I would like to see an increase in the informal seminars and bull sessions on teaching and professional self-development. Interested students might be invited. I would also like to see more participation by the Dean in YET activities. A word to the Dean: you are a highly respected and often rather nebulous person to your newest staff members. They may have met you and perhaps even heard you speak; but how about volunteering for an informal session where the young engineering teachers may ask questions on criteria for promotion, the relative importance of teaching, research, and consulting, and other important policies and procedures? A lot of questions remain unanswered because there is no chance to ask them.

Every engineering school in the country should have an active YET group. The activities would vary widely according to the local situation, but younger teachers need to get together to talk over common problems. If your school has no active YET group, get one started! A successful YET program requires the active cooperation and encouragement of the Dean and of the more experienced faculty members.

A reason frequently given for non-activity in YET groups is lack of time and the pressure of other commitments. Imaginative planning and scheduling can overcome this problem. An institutional YET program might be started as an informal luncheon-discussion meeting, with an occasional evening social activity.

Sectional Activities

Many sections have a YET program at the annual or semi-annual section meeting. The program may range from a special YET discussion table at lunch to a full-afternoon program running concurrently with other sessions. Probably the most successful section activity in the past year was a special two-day conference held by the North Midwest Section at the University of Wisconsin on "The Young Engineering Teacher—His First Five Years of Professional Development." One of the particularly interesting papers dealt with the young engineering teacher's responsibility for his own professional development.[3] This meeting could well serve as a model for section YET meetings.

National Activities

A number of YET activities operate on a national basis, with the close cooperation of section and institutional groups. Several YET sessions are held at each annual meeting. Incidentally, early plans for the Purdue meeting next June show a YET program of great interest to every young engineering teacher. Of course, YET's also attend many of the interesting general sessions at the annual meeting.

Other national programs of special interest to young engineering teachers include the summer employment clearing house and the summer school for YET's. The membership campaign for ASEE also has been conducted by YET.

The greatest opportunity for participation in YET activities is at the institutional level. Section meetings are also of great value. The national annual meeting is extremely interesting, but unfortunately too few of the younger engineering teachers are in a position to attend. The travel expenses are often high, and expense accounts don't often extend to the younger members of the teaching staff. National meetings are heavily populated by department heads and deans, but the instructor or assistant professor is rare. And yet these meetings

[3] Harold A. Foecke, JOURNAL, Vol. 49, p. 921 (June 1959).

could be tremendously stimulating to young teachers. I would like to suggest that each Dean take one young engineering teacher with him to the annual meeting, and arrange for the school to pay his expenses.

I have tried to present a few thoughts on the function of YET. I would greatly appreciate your sending me any comments and suggestions which you may have. I will pass them along to the appropriate member of our committee.

PRELIMINARY ANNOUNCEMENT
1960 ASEE-AEC SUMMER INSTITUTES ON NUCLEAR ENERGY

The following 8-week programs probably will be offered. For engineering teachers:

Basic, or Beginning

Reactor Physics, intermediate level

Radiation Effects on Engineering Materials

Radiation Effects, advanced level

Special Nuclear Studies

For technical institute teachers:

Basic, or Beginning

Your institution contributes one month's salary, AEC grants a matching amount to $750 plus transportation. For additional information see your dean—also next month's JOURNAL—or write to the office of the Secretary of ASEE.

COLLEGE-INDUSTRY CONFERENCE

The 12th annual College-Industry Conference will be held on the campus of Washington University in St. Louis, Missouri, on January 27–28, 1960. This year's Conference theme will be "The Young Professional Engineer—Our Mutual Responsibility."

For information write Don A. Fischer, Dean, Box 163, Washington University, St. Louis 30, Mo.

Definition of Engineering–A Counter Proposal

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Introduction

The ECPD Committee's proposed definition of engineering, appearing on page 624 of the March 1959 JOURNAL, and cited herein as No. 7, constitutes an interesting addition to the series of published definitional attempts that apparently started with Thomas Treadgold's 1827 formulation for Civil Engineering. (In Treadgold's day there were but two recognized kinds of engineering: Military and Civil.)

The recommendation represents the result of several years of deliberation by a highly select group of engineers. To challenge the adequacy of their offering does savor of temerity. Nevertheless it is strongly felt that it would be unfortunate were the committee's recommendation to go unchallenged and unchanged.

These are the contentions:

1. The proposed definition is unduly long and largely irrelevant; it is, in the main, a *dissertation on professionalism* rather than a *definition of engineering*.
2. It fails to mention one of the primary constituents of modern engineering –the manpower aspect–the mobilization, organization and direction of men–the effective utilization of essential human skills.
3. In phraseology it retains from some of the older definitions a touch of stilted redundancy.

Summary of Current and Former Definitional Attempts

Some familiarity with other current and former definitional attempts is prerequisite to valid criticisms and reasonable appraisals. From among various attempts to define the profession of engineering, a few of the better known are selected as representative. These are numbered from 1 to 8.

As mentioned, the earliest definition on record is that reported by Treadgold to the Council of the Institution of Civil Engineers (British) in 1827.

1. Civil Engineering is the art of directing the great sources of power in Nature for the use and convenience of Man, as the means of production and of traffic in states both for external and internal trade, as applied to the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange, * * *, and in the construction and adaptation of machinery, and in the drainage of cities and towns. [(1), p. 1736. See list of references appended]

This was a brave beginning but survives historically as a relic of former status and early concepts. In this definition may be noted much detailed enumeration and, among other things, the lack of mention of either the economic or the human or manpower aspects. Rather noticeable is the artificial or stilted redundancy or formalism in the use of such terms as "in Nature" and "the use and convenience of Man," something that has been carried over in some degree to most of the subsequent proposals. What others or alternatives are there?

In 1927 (just 100 years after Treadgold) a committee of the Mining and Metallurgical Society of America evolved a pair of definitions here designated as 2 (a) and 2 (b).

2. (a) Engineering is the practical application of scientific methods to the utilization of the resources of Nature for the use of Man.

(b) Engineering is the application of scientific methods to the utilization of the resources of Nature. [(1), p. 1736]

Definition 2 (a) was approved by but seven of the 95 members. The amended 2 (b) was approved by 34 members, and 44 members were satisfied with neither. A major objection was that either definition was applicable to many non-engineering occupations.

The late Dean Anson Marston (Past President and Lamme Medalist of ASEE), in connection with student seminars over the period 1906–1919, and also in connection with Land Grant College Engineering Association activities, evolved the following definition:

3. Engineering is the science and art of directing applications of the science of mechanics in the economic utilization of the forces and materials of Nature. [(1), p. 1737]

Number 4 is of unknown origin but was quoted by L. M. Gram in 1944 as a definition then current.

4. Engineering is the judicious and ingenious application of the principles of science to the economic production and use of materials and energy. [(2), p. 114]

As No. 5 is given a definition that has appeared on the title page of successive editions of *Who's Who in Engineering*. It was taken from the inscription that appeared on a symbolic mural painting by Fred Dana March (1910) that was formerly in the Engineering Societies Library in New York City.

5. Engineering: the art of organizing and directing men and of controlling forces and materials of Nature for the benefit of the human race. [(3), p. IX]

As numbers 6 (a) and 6 (b) are two of the current dictionary definitions (Webster's International and Funk and Wagnalls).

6. (a) Engineering is the art and science by which the properties of matter and the sources of power in Nature are made useful to Man in structures, machines and manufactured products, the occupation and work of a professional engineer. (4)

(b) Engineering is the science and art of designing, building or using engines and machines or of designing or constructing public works or the like, requiring special knowledge of materials, machinery and the laws of mechanics (5)

For ease of reference and comparison, the ECPD Committee's proposal is included as No. 7. Not included are the six paragraphs of supplementary "Explanations" that follow on the same page.

7. Engineering is the Profession in which a knowledge of the mathematical and physical sciences gained by study, experience and practice is applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the progressive well-being of mankind. (6, p. 624)

In 1953 the writer had occasion to devote considerable thought to this subject, having then evolved what is appended as No. 8. This proposal has not previously been offered for publication and is presented, not with a contention that it is *the* definition but rather with a belief that, for conciseness and adequacy of coverage, it does represent a definite forward step in the evolutionary quest.

8. Engineering is the application of science and art to the economic utilization of materials and forces in conjunction with the organization and direction of essential human skills.

Importance of an Adequate Definition

Since definitions are the building blocks of language and of law, the potential importance of a significant definition is of sufficient moment that it behooves him who would achieve definitional adequacy to be minutely critical and ploddingly patient, to "make haste" with the utmost of care and deliberation. Within the past two decades, for example, the profession of engineering has been seriously embarrassed from the lack

of certain clearcut definitional distinctions upon which legal interpretations could conclusively be based.

Essential Content of an Adequate Definition of Engineering

A definition needs to be incisive—terse but inclusive. The freer it can be of pros, cons, mere implications and of qualifying conditons and clauses, the better can it serve its function. Let us attempt to specify those items that are, individually and/or in the ensemble, indigenous to the profession of engineering; that separate engineering from any other profession; that characterize the profession of engineering and it only.

Engineering invariably relates to what can generally be designated as a project. The relationship of the engineer to the project includes one or more of the following: the concept, the plan or design, the construction or execution, the operation, and the maintenance or rehabilitation.

Implicit in the foregoing are the manufacture and/or the processing of the appropriate materials, the manipulation of forces and the sources of power to meet energy requirements, and the effective mobilization and coordination of essential human skills. In virtually all of its nonmilitary applications, as well as in many if not most, of the applications that relate to the military, modern engineering cannot be divorced from cost—the end-point accomplishment must entail a minimum of financial outlay. Emphasizing this aspect is the fact that the engineer is sometimes crudely defined as, "one who can accomplish with one dollar what any artisan could have done with two."

Here then are the "makings," the definitional ore to be processed.

Discussions and Comparisons

Used in their broader connotations the terms *science* and *art* as they occur in several of the definitions can be accepted as providing adequate coverage for the combined theoretical and applied aspects of the project. Definitions No. 1, 2, 5 and 6 are deficient in their failure to mention the economic aspect. All but No. 5 and No. 8 fail to take direct cognizance of the human factor,* the marshalling and amicably directing and effectively controlling the manpower aspects—the mobilization of essential human skills.

In No. 3 the use of the term "science of mechanics" might to some (the chemical or electrical engineer for example) seem a bit restrictive (by implication if not by strict Websterian interpretation).

In No. 4 the term "ingenious" might be questioned as carrying a connotation of improvization, wizardry or gadgetry, tending to imply agility or cleverness as opposed to the sturdiness that underlies the tenets of sound design and execution. It must be recognized and conceded, however, that ingenuity does enter importantly into virtually everything the engineer does—both in the planning and in the execution of the plan—the art. The writer is inclined, therefore, to accept the word "ingenious" as fully satisfactory when paired as it is with "judicious." Number 4 also takes direct cognizance of the "production and use of materials and energy." In the ultimate sense, of course, man *produces* neither of these but the conversion from one form to another is a major engineering function and the wording is probably defensible. It is felt that none of the definitions is strikingly deficient on this score. The two dictionary definitions (No. 6) reflect some of the strengths and weaknesses already discussed.

If there be agreement on what constitutes essential content, it follows that each of the first seven definitions is deficient on at least one count—most of them on several. Scrutiny for omissions or over-inclusiveness should be directed at the section which purports to outline the essential content of an adequate definition.

Specific Consideration of the ECPD Recommendation

As indicated at the outset, the primary criticism of the ECPD Committee pro-

* In a sense it can, by implication, be read into each of the other definitions but, as a vital constituent of ever-increasing importance, the manpower aspect surely merits and demands more than an indirect, inferential inclusion.

posal (No. 7) is that it is unduly long and largely irrelevant, that it is, in the main, a *dissertation on professionalism* rather than a *definition of engineering*. Let us now explore the basis for this contention.

Engineering, as here used, corresponds to the terms law, medicine, architecture, theology, etc. In each case it is the profession of law, medicine, theology or engineering that is under discussion. The term "profession" as applied to any area of specialization means certain things, things which are common to all professions. Implicit in any (and every) profession must be an appropriate backlog of specialized knowledge, minimum standards of educational and practical preparation, leeway for the exercise of judgment and a rigorous code of ethics. *Since the term "profession" means exactly the same things when applied to one profession as it does when applied to another, it has no place in a definition that is designed to distinguish one profession from the others.*

The ECPD proposal contains 41 words. Virtually all of the first 25 words are devoted to telling us: "that engineering is a profession"; "that the practice of engineering requires specialized knowledge"; "that this knowledge is to be gained in certain ways"; and "that the exercise of judgment is essential in the application of that knowledge." Mention of the mathematical and physical sciences constitutes the only distinctive item within the first 60% of the definition. The remaining 40% is routine, but even it, as has been pointed out, is both non-inclusive and burdened with some of the stilted carry-over phraseology of the original Treadgold version.

Operational Differences between Engineering and Other Professional Groups

Aside from the definitional aspects, each profession has what might be termed its "operational characteristics" which represent the cumulative effects of size, complexity, relative maturity and clientele. These also influence and are influenced by the environment in which the profession operates, its organizational structure and the general character and attitudes of its membership. Included in this category would be the degree of uniformity and rigor with which it sets and enforces its standards of admission to practice—the type and quality of its screening operations.

Not only has our thinking been muddied by the lack of a clear-cut distinction between that which is professional and that which is definitional, but there has long been, with most of us, a failure to recognize certain inherent operational differences between professions, differences that simply can't be picked up or successfully adapted to another profession.

Hardly ever does the subject of engineering professionalism arise, that the medical profession or the law is not drawn into the picture as an ideal to be emulated. Some of the observed differences of which we are prone to be envious are due to inherent clientele relationships; others, in considerable measure, to the relative youth of engineering as a profession. These latter might, in due course, be erased, but not the former. Our standards and screening processes continue in the state of flux in which, in some degree, they should always be.

Whether or not our educational preparation is more narrow or our pre-professional specialization less exacting than those set by other professional groups may be open to question, but at least the other groups have, in most cases, upgraded themselves by extending the periods of preparation for practice.

As long as such differences exist we can expect some sniping on the part of companion professional groups, but that in itself constitutes no reason why we should either feel a need for change, or feel inferior because we don't change. We should, however, be critically self-appraising and always ready to inaugurate changes when and if we decide that they are logically and feasibly in order.

Probably the major distinction all too often overlooked lies in the relative types of clientele served by engineers in contrast with most of the other professions. The relationship of the doctor, the architect and the theologian to his client is highly personal, each in its own distinc-

tive way. The engineer generally finds himself rather impersonally serving groups and organizations. Any close sense of personal gratitude is simply not a part of his type of practice, or one of its rewards.

In these respects the clientele of the corporation lawyer may resemble that of the engineer; that of most other lawyers carries, in high degree, the personal relationship. Much of the legal area dovetails almost automatically with politics and/or headlines. No profession is probably farther from any natural tieup with politics and/or headlines than is that of engineering.

Recognition and appreciation of such inherent basic differences between the operational aspects of the professions can add both to the clarity of our thinking and to our professional self respect and poise. We as engineers need to recognize that to be different is not necessarily to be inferior. As stated before, we do, as professionals, need to be critical of ourselves and always open to betterment, but even more, perhaps, we need to overcome a tendency to be envious, apologetic and defensive with respect to our relative status and to the quality of our professionalism.

If the ECPD Committee feels that our status as professionals is really as shaky as is inferentially indicated, there are two non-definitional remedial measures that might well be considered:

1. Re-examine our screening procedures. The definition of a specific profession is one thing; the rigor or laxity of our procedures for admission to the practice of the profession is another.

2. Inaugurate as an independent venture an educational crusade on the nature of, and need for, a stronger professionalism in engineering. Both in the wording of the Committee's definition and in the "Explanations" (6, p. 624) many true and excellent things bearing upon such a project are well said and could be utilized therewith.

In closing let the author re-state his conviction that the needed definition should be simple and terse, not hedged about with elaborating or qualifying pros and cons; it should be devoid of anything that might make it appear defensive or apologetic. The identifying characteristic of our profession is that it is a composite of science, art, economics, and human skills as applied to the beneficial utilization of materials and forces. Each major constituent should be included positively; not one of them should be left to inference.

This discussion is submitted and its length is justified not as an attempt to discredit or belittle the Commitee's commendable but questionable endeavor to define engineering. It is rather an attempt to join hands with the Committee in re-emphasizing the timeliness and importance of the project and to contribute to the successful attainment of the announced objective. As something subject to further study and improvement the writer proposes the following 27-word definition of engineering: *Engineering is the application of science and art to the economic utilization of materials and forces in conjunction with the organization and direction of essential human skills.*

References

(1) Marston, Anson, "Engineering and Engineering Education" (ASCE Presidential Address). ASCE *Transactions* (Paper No. 1721), Vol. 93, pp. 1736–1744 (1929).

(2) Gram, L. M., "Engineering a Profession." JOURNAL, Vol. 52, pp. 114–118 (1944).

(3) March, Fred Dana, "Definition of Engineering." *Who's Who in Engineering*, 8th ed., p. IX (1959).

(4) Webster, *New International Dictionary*, 2nd Ed. (1950)–1952 printing.

(5) Funk & Wagnalls, *New Standard Dictionary of the English Language*, 1952 Edition, 1956 printing.

(6) O'Sullivan, G. H., "Definition of Engineering proposed by Recognition Committee of ECPD." JOURNAL, Vol. 49, No. 7 (March 1959), p. 624.

Mechanics Division Bulletin

Executive Committee

A. Higdon, Ch.....1960	H. R. Lissner*.....1961	E. P. Popov.....1962
L. A. Smith.....1960	J. O. Smith.....1961	F. P. Beer.....1963
D. R. Carver.....1961	E. J. Marmo.....1962	D. C. Drucker.....1963

Secretary of the Mechanics Division: Carl H. Cather, Department of Mechanics, West Virginia University, Morgantown, West Virginia.

Editor: Arthur W. Davis, Department of Theoretical and Applied Mechanics, Iowa State University, Ames, Iowa.

Chairman's Message

ARCHIE HIGDON

Professor and Head of Mechanics
U.S.A.F. Academy, Colorado

Everyone gives "lip service" to good teaching, but how many really put forth the necessary effort to achieve it? The secret of good teaching is careful, effective preparation for every appearance in the classroom. Certainly, adequate graduate training, a breadth of knowledge that extends into related areas, and practical experience are essential. However, these requisites alone do not assure the student a successful educational program.

How many times have you complained about your students' lack of interest in Mechanics? We all hear these statements frequently, but what have we done to augment the interest of the keen young minds in our classes? What right do we have to assume that our students understand why they should study Mechanics?

Lesson preparation must include the finding of adequate and effective motivational material to explain the necessity for student mastery of the topics assigned. If there is no reason for study of the topic, perhaps it is time to introduce more relevant material.

At the Air Force Academy, cadets are placed in sections according to performance in the subject. In many instances young men are in the bottom section because of lack of interest in the subject—not because of lack of ability. It is a real pleasure to see the progress these men make in cases where our teachers are successful in motivating them. Undoubtedly, a teacher's toughest problem is to properly motivate his students. Many teachers completely overlook this major area.

One solution to the problem lies in teacher-training programs. These programs, conducted at departmental level, pay real dividends. The new instructor is able to learn effective methods of presenting lessons before he enters the classroom and can draw upon the resources of the entire department for current motivational material. It is hoped that every school has, or will inaugurate, a carefully planned and adequately manned teacher-training program. I am sure the end result of such programs will be improved and more effective teaching methods.

* Division Representative on the General Council.

The National Standard Examinations in Mechanics

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New York University
New York, New York

The purpose of these examinations was to provide a standard of comparison whereby a school could independently and anonymously check how effectively it was presenting its courses in mechanics. Each school would thereby have the opportunity to evaluate individually its performance considering such variables as the effect of its time allotment, the quality of its staff and of its students, and possibly of the textbooks used.

Each participating school was supplied with a copy of the examination, the answers, a detailed grading outline, and report forms. To insure anonymity, the report forms were placed in a sealed envelop addressed to the committee, but mailed in another envelop to the Secretary of ASEE who then forwarded the enclosures to the committee.

Selecting the Examination Questions

In order to obtain a representative examination, requests were sent to 40 schools across the nation asking for copies of their last three examinations in statics, dynamics, and strength of materials. The response was unanimous and the examinations showed close agreement in the fields covered, especially in statics and dynamics. However, the scope and complexity of the problems were so varied that no two members of the committee chose the same problem for the standard examination. Consequently, it was decided to have each member of the committee limit himself to a particular field and submit two problems on this field. One of these problems was selected from the submitted examinations and one was his original composition. From these, the final selections for the standard examinations were made. In statics, the problems were on truss analysis, equilibrium, friction, non-coplanar forces, and centroids and moments of inertia of areas. In dynamics, the problems covered kinematics of plane motion, force-acceleration analysis, impulse-momentum, work-energy, and dynamic reactions by dynamic equilibrium or resultant effective forces.

Presented at the June 1959 Annual Meeting of ASEE, at the University of Pittsburgh. Recommended for publication by the Mechanics Division.

Analysis of Results

In November 1958, copies of the examinations were sent to approximately 100 colleges of engineering from every section of the nation. By February 1959, reports were received from 79 schools of which 50 were on statics and 29 on dynamics. In a few instances, reports were received from the same school on both statics and dynamics. The indications are that 75% of the schools requesting the examinations used them, a gratifying measure of national interest in the project. Separate analyses of the results for statics and for dynamics will now be presented. The two appendices at the end of this report give each school's performance.

Statics

To obtain true averages, the number of students on each report was multiplied by the average grade reported on each problem and on the entire examination. These values were then totalled as line 1 of Table I. The average grade attained by 5,632 students from 50 schools was 49.3%. The highest and lowest averages reported were respectively 63.7% and 38.1% for junior students and 60.7% and 25.0% for sophomore students. The most difficult problems were numbers 2 and 5, while the easiest was Problem 4.

TABLE I

STATICS EXAMINATION

Schools Reporting	Total Number of Students	Prob. 1 Truss Analysis	Prob. 2 Equilibrium	Prob. 3 Friction	Prob. 4 Non-Coplanar Forces	Prob. 5 Centroids, Moments of Inertia	Examination Average
50	5,652	57,916	46,288	59,121	66,262	48,998	278,585
Average grade on maximum of 20 points (Also average % of total examination)		10.24	8.20	10.46	11.74	8.66	49.3
Average % on basis of 20 points		51.2	41.0	52.3	58.7	43.3	
% deviation from examination average		+3.85	−16.82	+6.08	+19.06	−12.17	
Average grade of sophomores from 35 schools		9.88	8.01	10.52	11.80	8.84	49.05
Average grade of juniors from 15 schools		11.36	8.74	10.37	11.52	8.20	50.19
Average grade of 653 sophomores in 2 credit-hr. course in 5 schools		8.59	6.83	10.79	10.87	10.12	47.20
Average grade of 421 juniors in 2 credit-hr. course in 4 schools		12.92	10.81	10.37	11.10	9.47	54.67

An analysis of the students taking the examination showed that 73.2% were sophomores, 25.6% were juniors, and 1.2% were seniors. A comparison of those schools where predominately sophomores took the examination with those where predominately juniors took the examination shows the average overall performance of the juniors to be slightly better than that of the sophomores. This might have been expected because of the greater maturity of junior students. However, this better performance is outstanding only in Problem 1 where numerical accuracy was stressed. In fact, the sophomores did better than the juniors on Problems 3, 4, and 5. The conclusion seems to be that statics can be taught as effectively to sophomores as to juniors.

As far as course credit is concerned, all 50 schools assign 3 credit hours except 9 schools in which the credit varied from 1.8 to 2.25 hours, and one school which apparently assigns 4 credit hours. For further comparison, the results reported for the 9 schools having a 2-credit course are divided between sophomores and juniors at the end of Table I. The 653 sophomores attained an examination average of 47.2% whereas the 421 juniors achieved an average of 54.7%. Comparison of these results with the overall examination average of 49.3% seems to indicate that for juniors a 2-credit course will be satisfactory, probably because of their greater maturity. However, the average of 50.19% for all juniors cautions that the 2-credit juniors were probably a better than average group. Actually, the 2-credit juniors represent only

30% of the junior group and only 7.5% of all students taking the examination.

Not all schools reported on the number of correct solutions achieved. Of those which did, the per cent of correct solutions obtained by 3,554 students were: Prob. 1–11.6%; Prob. 2–5.7%; Prob. 3–15.9%; Prob. 4–25.2%; Prob. 5–5.7%. Once again, the relative difficulty of Problems 2 and 5 is evident, as is the relative success with Problem 4.

Dynamics

A similar analysis on the results of the dynamics examination is tabulated in Table II. The average grade attained by 2,856 students from 29 schools was 49.2%. The most difficult problem was Problem 5 dealing with dynamic equilibrium, with Problem 3 on impact being next most difficult. The remaining three problems were fairly even with most success on work-energy.

An analysis of the types of students disclosed that only 440 or 16% were sophomores, the other 84% were juniors. The highest and lowest averages reported were respectively 64.3% and 33.2% for juniors, and 62.0% and 39.0% for sophomores. Since the sample includes only 4 schools where sophomores took the examination, this comparison is probably not significant. Even so, the tabulation shows the average performance of the sophomores to be only slightly below that of the juniors except in the work-energy problem where it is distinctly lower.

Of the 29 schools, all assign 3 credit hours to dynamics except 5 schools which assign 2 to 2.5 credit hours. Of these five, only one was a sophomore group.

TABLE II

DYNAMICS EXAMINATION

Schools Reporting	Total Number of Students	Prob. 1 Kinematics	Prob. 2 Force-Acceleration Analysis	Prob. 3 Impulse-Momentum	Prob. 4 Work-Energy	Prob. 5 Dynamic Equilibrium	Examination Average
29	2,856	31,268	33,490	23,467	35,171	17,068	140,464
Average grade on maximum of 20 points (Also average % of total examination)		10.96	11.72	8.24	12.32	5.97	49.2
Average % on basis of 20 points		54.8	58.6	41.2	61.6	29.8	
% deviation from examination average		+11.4	+19.1	−16.3	+25.2	−39.4	
Average grade of 440 sophomores from 4 schools		9.80	11.08	8.16	9.88	5.22	44.14
Average grade of 2,416 juniors from 25 schools		11.15	11.83	8.25	12.76	6.11	50.10
Average grade of 237 sophomores in 2 credit-hr. course in 1 school		10.57	11.00	8.09	11.08	4.19	44.90
Average grade of 185 juniors in 2 credit-hr. course in 4 schools		9.52	12.42	9.48	12.58	7.02	51.02

As shown in Table II, the performance of this 2-credit sophomore group was far below that of the corresponding junior group. Of this latter group, the highest average attained on the examination was 55.5% which was considerably below the 64.3% maximum score of the 3-credit group of juniors. As in the statics examination, the average performance of the 2-credit junior group was somewhat better than that of all juniors. This difference suggests that they were a select group. Statistically, the 2-credit juniors are 7.66% of the entire junior group and only 6.47% of all students taking the examination. The sample seems to be too small to conclude that a 2-credit course is satisfactory for juniors.

Conclusion

It is the sincere hope of the committee that these performance records will be of benefit to the participating schools. Where improvement seems indicated, it is hoped this will occur. Certainly the establishment of a national norm, unsatisfactory though it may be from the standpoint of problem selection and of grading outline, should be of some use to each participating school in rating its individual performance. Perhaps in a few years, a new improved series of examinations may be a desirable follow-up. Should you desire to participate in the next series, which will include strength of materials, please write to the chairman.

Archie Higdon
Herbert R. Lissner
Herbert F. Marco
Gerald Pickett
William B. Stiles
Ferdinand L. Singer, *Chairman*

APPENDIX I

Dynamics

School	Number of Students	Course Credit Hours	Prob. 1 Kinematics	Prob. 2 Force Acceleration Analysis	Prob. 3 Impulse Momentum	Prob. 4 Work Energy	Prob. 5 Dynamic Equilibrium	Examination Average
1	161	3	12.6	12.7	9.6	13.7	7.1	55.7
2	198	3	14.5	11.8	12.7	15.2	10.1	64.3
3	156	3	7.1	13.4	3.8	14.0	3.7	42.0
4	69	3	11.6	12.7	7.7	12.7	4.6	49.3
5	126	3	7.8	11.0	8.0	6.5	5.7	39.0
6	64	3	9.3	12.9	11.6	9.3	7.7	50.8
7	23	3	12.2	16.4	11.0	13.4	8.8	62.0
8	79	2.5	8.3	12.1	8.5	12.1	6.1	47.1
9	99	3	12.1	10.4	8.2	11.7	5.8	48.2
10	48	2.5	9.7	11.8	10.7	14.9	8.4	55.5
11	46	3	12.5	11.8	9.6	13.6	2.4	49.9
12	69	3	14.7	14.0	8.3	15.2	5.0	57.0
13	94	3	13.3	11.5	8.1	12.5	2.6	48.0
14	256	3	11.7	13.0	9.8	12.6	6.8	57.7
15	237	2	10.6	11.0	8.1	11.1	4.2	45.0
16	61	3	6.5	13.7	8.3	10.8	9.4	48.7
17	41	3	12.6	10.0	7.6	13.1	3.9	47.2
18	54	4	10.1	9.3	7.4	10.9	7.1	44.8
19	19	2.5	14.0	16.3	7.1	12.1	4.3	53.8
20	182	1.2	9.1	11.0	—	—	—	—
21	104	3	10.5	13.6	9.3	11.2	7.1	51.7
22	188	3	5.1	8.7	5.1	10.8	4.7	34.4
23	240	3	11.5	11.3	9.0	15.4	7.9	55.1
24	140	3	7.0	10.9	3.2	11.2	0.9	33.2
25	139	3	12.2	8.8	5.5	10.1	5.3	41.9
26	17	4	9.6	11.5	8.0	11.3	11.2	51.6
27	39	2.5	9.5	11.9	11.1	10.9	8.5	51.9
28	53	3	11.1	13.1	7.5	12.7	5.7	50.1
29	36	3	8.9	15.2	12.6	13.0	8.8	58.5

APPENDIX II

STATICS

School	Number of Students	Course Credit Hours	Prob. 1 Truss Analysis	Prob. 2 Equilibrium	Prob. 3 Friction	Prob. 4 Non-Coplanar Forces	Prob. 5 Centroids Moments of Inertia	Examination Average
1	220	3	10.4	4.1	11.7	12.7	8.8	47.7
2	174	2	9.5	8.3	12.6	13.3	14.2	57.9
3	41	3	10.3	7.3	8.5	7.5	7.3	40.9
4	79	3	10.3	8.2	12.6	10.7	7.2	49.0
5	26	3	10.8	13.2	10.2	13.4	12.5	60.0
6	134	2.25	9.6	9.6	5.0	8.2	7.9	40.2
7	74	3	12.9	8.9	16.2	13.0	12.2	63.2
8	19	3	8.4	6.6	15.7	15.5	8.0	54.2
9	118	3	9.0	7.9	10.4	11.4	7.2	45.9
10	248	3	8.1	10.2	8.2	11.6	12.9	51.1
11	66	2	9.1	4.0	9.1	10.4	6.9	39.5
12	35	2	7.2	7.1	14.4	11.2	9.7	49.5
13	104	3	11.9	8.9	9.2	14.6	10.4	55.1
14	12	3	17.0	9.0	14.0	9.0	12.0	61.0
15	23	3	8.6	7.9	8.5	7.4	11.3	43.7
16	90	3	10.4	8.4	10.6	12.1	6.9	48.3
17	72	3	5.4	2.2	5.4	7.4	6.7	25.0
18	97	3	9.8	6.5	8.8	8.3	7.9	41.3
19	91	3	11.1	7.3	9.4	7.6	6.4	41.8
20	159	2.67	9.2	9.6	9.5	11.8	8.2	48.3
21	—	4	7.8	9.8	15.6	14.4	—	—
22	60	3	10.0	5.8	10.7	10.9	9.6	47.0
23	46	3	9.5	6.9	10.4	10.2	4.6	41.6
24	51	3	12.6	8.2	13.8	16.6	—	—
25	279	3	12.1	7.8	11.4	11.2	6.6	49.1
26	79	2.5	14.0	10.8	12.1	16.8	10.0	63.7
27	116	2	12.8	7.2	7.5	10.4	9.6	47.5
28	47	3	14.0	12.0	11.7	12.6	9.3	60.0
29	162	3	10.3	10.2	12.6	10.0	10.8	53.9
30	155	3	7.5	7.9	6.8	9.5	6.3	38.1
31	114	4	8.8	6.3	13.9	9.4	6.6	45.0
32	146	3	7.5	3.8	9.7	11.9	8.1	41.1
33	63	3	8.9	7.1	9.5	10.7	9.5	45.6
34	25	3	11.6	7.5	11.0	11.0	10.9	52.2
35	518	3	9.0	9.3	11.1	11.7	10.8	51.8
36	235	3	12.1	8.2	8.6	14.1	6.0	49.0
37	244	2	7.5	5.0	12.6	10.7	9.4	45.2
38	85	3	11.3	7.8	12.8	12.2	9.9	54.0
39	81	3	11.2	5.7	9.4	10.5	6.6	43.4
40	100	3	12.0	8.2	12.1	9.1	7.1	48.5
41	44	2.5	13.4	12.7	11.9	11.3	12.3	61.6
42	182	1.8	12.4	12.7	11.1	9.2	8.1	53.5
43	194	3	15.0	8.1	15.9	16.8	—	—
44	151	3	12.4	8.4	7.9	9.4	8.2	46.3
45	73	3	10.0	6.0	10.7	13.6	12.9	53.2
46	136	3	7.5	7.8	9.9	10.4	6.8	42.4
47	301	3	13.7	11.3	11.0	14.3	10.4	60.7
48	172	3	9.8	9.5	11.0	9.2	5.6	45.1
49	27	3	13.0	11.0	17.0	10.0	11.0	62.0
50	129	3	9.5	7.2	9.8	10.7	8.2	45.3

Introducing Engineering Students to Fluid Mechanics

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> It is, in fact, nothing short of a miracle that the modern methods of instruction have not yet entirely strangled the holy curiosity of inquiry; for this delicate little plant, aside from stimulation, stands mainly in need of freedom; without this it goes to wrack and ruin without fail.—Albert Einstein.

The writer acknowledges a significant contribution by Dr. J. William Holl, Assistant Professor at the same University and Laboratory.

Introduction

The problem of introducing engineering students to fluid mechanics will be discussed here in relation to, and as part of the overall problem of undergraduate education in engineering. As implied by the title, this problem will be outlined without endeavoring to find a definite solution. Indeed, this writer believes that there should not be a unique answer to this problem since the variety of solutions offered by different teachers and engineers appears to be the only way to meet the corresponding variety in the thinking of students.

The writer discusses the problem from the point of view of the teacher as well as from that of the employer of engineering graduates in the field of research and development. He feels that in the light of present-day technical requirements the preparation of engineering graduates is clearly deficient and that the problem discussed here is therefore part of one of the most serious problems of our times.

The views expressed are personal opinions of the writer, and are not to be interpreted as being in agreement or in disagreement with views or educational policies at The Pennsylvania State University.

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What Should Be Taught?

The explosive expansion of engineering during the last decades places a new situation before the teachers of engineering. If engineering were to be taught today with the same attention to specific areas of application as was possible half or even a quarter of a century ago, one of two major changes would have to be made—either to divide engineering education into a much larger number of fields than is traditional, compelling the student to choose a narrow specialty practically from the start of his professional education, or to double the time devoted to undergraduate education. The first solution would deprive us of broadly educated engineers competent to direct major engineering projects; the second, even if it were possible, would delay the time of entrance into practical engineering work to such an extent as to present an intolerable engineering manpower problem.

The answer that is being given today is, of course, that we are teaching in our

undergraduate schools only the "fundamentals" of engineering, leaving specialization to the subsequent career of the engineer or to postgraduate studies. This answer is quite reasonable but it leaves at least two problems open: first, what are truly "engineering fundamentals"? and second, are we willing to accept the practical consequences of this principle?

Addressing ourselves first to the second question, the practical consequence would be that we can no longer aim to "train" our engineering students to become proficient in the execution of specific engineering tasks. The writer believes this consequence to be quite inescapable, but it must be admitted that it is in conflict with the frequently held contention that "our graduates are expected to know how to measure the flow of water with an orifice meter or a weir." This they can learn in the field if they are "well educated" in a sense the writer hopes will become clearer in the course of this discussion, and if they have come to know the process of application by a few carefully treated examples. THIS MEANS THAT WE ARE TO PREPARE OUR GRADUATES TO LEARN FOR THEMSELVES WHAT THEY WILL NEED TO KNOW.

The preceding conclusion obviously returns us to the first question, what are "engineering fundamentals"?

Today engineering is applied science, or the application of science, and the sciences to be applied are obviously an essential part of the "fundamentals" in the field of engineering concerned. The sciences fundamental to fluid mechanics are mathematics and classical physics; indeed, fluid mechanics may well be considered as a part of classical physics.

The logical consequence of this reasoning is that undergraduate work for future engineers should consist of mathematics, physics, and chemistry, with only slight modifications according to the plans for a future career. Fluid mechanics would then appear as part of a course on the mechanics of continuous media.

The last conclusion is essentially correct, because modern engineering demands categorically a thorough understanding of the underlying mathematical-physical principles.* The better our graduates acquire this understanding, the better they will be prepared to meet the requirements of the future. Nothing that will be said in this paper should be interpreted as being in conflict with this fact.

Yet, in addition to this knowledge of the mathematical-physical principles, the engineer needs something else—namely the ability and the interest to use this knowledge for the solution of practical problems. It is particularly in the creation of a *new* structure, machine, or process that modern engineering often fails to meet the demands of our times. Though we do not know exactly how to cultivate this creative ability, we do know that it depends to a large extent on the specific ability to think geometrically in three dimensions and in concrete physical terms. Thus, in addition to a thorough knowledge of certain chapters in the book of nature, which is written in mathematical symbols, the engineer needs a vivid and dependable mental picture of the geometric and physical meaning of every symbol and operation involved. This necessity must be recognized from the beginning in the presentation of a physical subject such as fluid mechanics.

Thus in answer to the question of *what* should be taught, we found first that we cannot teach all foreseeable applications. Instead we must teach the underlying mathematical-physical principles thoroughly, and in addition must create a dependable mental picture of the geometric and physical meaning of every element of knowledge. The applications can only be *illustrated* by relatively few examples, selected in accordance with the personal experience of the individual teacher.

* Dr. Theodore von Karman pointed out that an engineer must know the principles of the mathematical-physical sciences *as they really are*, although he cannot be expected to master details of these sciences as well as the mathematician, physicist or chemist.

How Should the Subject Be Taught?

So far the problem of teaching fluid mechanics to engineers has been outlined only with respect to the subject in relation to the technical requirements of engineering. This consideration fails to recognize the abilities and interests of the students as an essential element in the problem of teaching engineering. The latter is, in fact, one of the most important aspects of this problem since any success in engineering education is highly doubtful as long as undergraduate students are motivated chiefly by the desire to achieve their degrees or by the fear of failure to do so.

Competent engineering educators have suggested that our students must be expected to recognize the necessity of studying engineering the way it really is, not the way individual students would like to have it. In other words the subject should not be adjusted to the interests or abilities of the students. Bypassing the psychological problems involved, this contention could be valid only if the requirements of what should be taught were "singled-valued." It has been shown, however, that this is not true insofar as the engineer needs a thorough knowledge of the mathematical-physical principles as well as the ability to imagine creatively new forms or combinations of elements before they exist. Thus variety in the abilities and interests of students is found to agree with the practical requirements of actual engineering work.

Our present ways of teaching, particularly in schools that emphasize the scientific content of modern engineering, reward and cultivate almost exclusively the ability to think abstractly and to handle formal operations with mathematical symbols. Since neither the necessity nor the value of mathematical procedures can be questioned, one might ask whether this emphasis in modern engineering education is not fully justified.

There can be no doubt that we need today engineers with a better knowledge in the mathematical-physical sciences than was offered by the older type of conventional training in the classical fields of engineering. However, as indicated before, there exists also a desperate shortage of engineers capable and willing to produce a *new* structure, machine, process. This situation has been recognized by the current interest in "creative engineering," clearly demonstrating that we have lost some of this all-important aspect of true engineering. It has already been pointed out that creative ability in engineering is usually dependent, among other things, on the special ability to visualize geometric or physical combinations in three dimensions. This ability, however, might occur as an *alternate* to the ability of abstract thinking and procedure according to established rules. Thus the natural selection connected with today's methods of teaching engineering may eliminate some of the most promising engineering students, namely those whose thinking is predominantly geometric or physical.

Furthermore, it must be admitted that present-day engineering curricula offer relatively little opportunity or incentive to develop and to exercise creative abilities. The writer recalls the thrill he experienced as an undergraduate when he designed for the first time a simple machine, feeling the ability to calculate the required moment of inertia of the flywheel, the size of the beam that had to withstand the calculated loads, and the power and speed changes of the driving motor. It was all very simple, but it connected for the first time the abstract subject of mechanics with the practical world of engineering. We are largely depriving our students of this thrill of simple accomplishment.

The pressure of the ever-expanding curriculum and the increasing complication of engineering subjects make it quite difficult today to satisfy this more than welcome desire of practical accomplishment in engineering. The answer to this problem is no doubt hard to find. However, until we see our way more clearly we should at least insist that the ability to reason geometrically and in direct physical terms can achieve some recognition in competition with the ability of abstract thinking and procedure.

The Teaching of Fluid Mechanics

On the basis of the foregoing considerations, an attempt will now be made to arrive at some general conclusions with regard to the problem discussed in this paper:

Considering that in our times only fundamental and broad subjects can be tolerated in our undergraduate engineering curricula, the first question to be answered is whether or not fluid mechanics is such a subject.

The answer is believed to be "yes," provided "fluid mechanics" deals with something of more general significance than the particular flow problems concerned. This is true, for example, as far as it constitutes an introduction to the treatment of VECTOR FIELDS. Other examples are the concept of the boundary layer, the theory of turbulence, and the principles of similitude, all of which have significance well beyond the field of fluid mechanics. If, for example, electrical engineers receive their introduction to the mechanics of vector fields in terms of electrostatics or magnetostatics, a course in fluid mechanics may not be necessary. However, the flow of fluids seems to offer a particularly favorable example for illustrating the physical facts and the meaning of the mathematical symbols used to describe such fields. In fact, the student who finds vector analysis difficult to grasp as an abstract discipline should be given the opportunity to study this discipline first in terms of the physical concepts of fluid mechanics.

Does this mean that fluid mechanics teaching should start with two- or three-dimensional flow problems? This writer believes the answer is "no," not only because of the power of one-dimensional reasoning as a tool, but principally because *it is essential for engineers to start any consideration of a new field by the simplest theoretical means possible.* It should be shown to what type of flow problems the one-dimensional approach properly applies and where it breaks down. The flow over an airfoil in the infinitely extended stream is an excellent example for the limits of one-dimensional reasoning. The concept of circulation can be introduced here to good advantage even if this is the first time that the class is confronted with the concept of a line integral. The necessity of this apparently complicated reasoning should be evident from the previously demonstrated failure of one-dimensional concepts to meet the actual physical situation. Engineers will be interested in the tie between one- and two-dimensional reasoning demonstrated by cascade considerations of turbomachinery.

The principle of a "conservative vector field" in terms of a potential flow field should be introduced. The presentation should include the geometric properties of such a field. The potential lines or surfaces may be introduced as "cross-sections" of the flow, and then related to the rigorous mathematical description. Whether two- or three-dimensional flow fields should be considered first depends entirely on the teacher.

The limits of the theory of "perfect" fluid must be strongly brought out because they involve the general principle of the boundary layer in connection with the idea that any theory has but a limited range of physical applicability. However, the extent to which frictional effects are considered depends entirely on the particular course or teacher. Since it is hopeless to try to cover everything, no effort is justified to cover "as much as possible." It is much more important to discuss whatever is covered quite thoroughly and, if possible, from more than one point of view. The physical and geometric concepts require considerable time for a good presentation, because they must be coupled with the mathematical language.

To meet diverse abilities among the students as well as different requirements in practice, it may be well to conduct different, parallel courses in fluid mechanics. Rather than divide the treatment of the subject according to fields of application (such as fluid mechanics for civil engineers, for mechanical engineers, for aeronautical engineers) it may be better to divide it by the form of treatment, i.e., according to the philosophy and experience of the teacher. A highly

systematic, mathematical treatment may be as important for civil engineers as for aeronautical engineers, and the same is true for a form of treatment on a more geometric-physical basis. As long as this division does not ignore the geometric-physical aspects in the first treatment and includes a good mathematical presentation in the second, the student should be free to select, under competent guidance, either form of treatment, since both treatments can cover essentially the same field of subjects.

The most difficult requirement to meet in the teaching of fluid mechanics is that of presenting practical examples capable of meeting the natural desire and the practical need of creative accomplishment. It is hoped that available experience and knowledge in the teaching of "creative engineering" can be used in fluid mechanics (as well as in other disciplines of engineering) at an early state in the development of this subject. It seems that simple momentum considerations, principles of similitude, and perhaps some energy considerations can be used very early to guide the students in seeking simple, approximate answers to some questions to which the individual student would like to find an answer. At all events a determined effort is indicated to meet this perhaps most important of all requirements regarding engineering education.

Conclusions

Some conclusions that have emerged from the preceding remarks can be summed up as follows:

a. To strive for completeness of coverage is hopeless. The objective cannot rightly be to enable the student to carry out specific operations, but only to illustrate to him the path of reasoning from the simplest concepts and observations to more advanced ideas involving, for example, that of a vector field.

b. The subject matter should always be selected according to the experience of the teacher so as to permit the most vivid demonstration of general principles by a few practical examples.

c. Uniformity of subject treatment is not only unnecessary but undesirable. Variations in treatment between different teachers and courses are necessary to accommodate different types of thinking among the students, as well as different requirements in practice.

d. The physical and/or geometric significance of mathematical symbols and operations should constitute a major part of the presentation.

e. A serious attempt should be made to permit an early, simple application of the subject covered to some practical situation, giving the students an opportunity to use educated imagination and personal initiative.

CONFEDERATION OF ENGINEERING PROFESSION IN CANADA

The Engineering Institute of Canada has announced that, as a result of a plebescite of its corporate members, about 95% of those voting were in favor of continuing negotiations with the Canadian Council of Professional Engineers, with the object of joining a single national body that would consolidate these two organizations.

As a result of this vote, the Engineering Institute of Canada will now proceed, jointly with the Canadian Council of Professional Engineers, to establish the Engineers Confederation Commission. This new 25-man Commission will be charged with the responsibility of drawing up detailed proposals for a charter and by-laws for the suggested new national body. These proposals will then be submitted to the membership of both bodies for ratification.

Deflection of Beams

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Recommended for publication by the Mechanics Division

Introduction

Over twenty years ago, Hetenyi (1) published an exquisite method of solving problems of beam deflection. This method does not seem to have received any attention in this country, although Conway (2) has noted it in a British text. Professor Hetenyi's work is based on an assumed Maclaurin expansion of the equation of the elastic line, but as originally presented, the method did not account for discontinuous loads on the beam, and this may be the reason why it has not gained popularity. The purpose of this note is to correct this shortcoming and to attempt to publicize Hetenyi's work. This method appears to the writer to be so clear and easy to use as well as being more rapid than other known methods that it is well worth inclusion in first courses on strength of materials. The particular advantage is that statically indeterminate beams are as easily set up as statically determinate ones.

The equation to be solved is for a uniform beam:

$$D^4y = q/EI \tag{1}$$

where $D = d/dx$ and $q = q(x)$ is the load per unit length on the beam. EI is the stiffness.

The solution of Eq. (1) is:

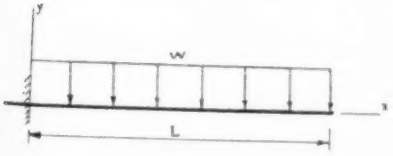

FIG. 1.

$$y = C_0 + C_1x + C_2\frac{x^2}{2!} + C_3\frac{x^3}{3!} + \frac{1}{EI}D^{-4}q(x) \tag{2}$$

where $D^{-1}q(x) = \int_0^x q(x)dx$, an indefinite integral of $q(x)$.

Since we obtain $D^{-4}q$ by integrating $q(x)$ from zero to x four times in succession, it follows that $D^{-1}q = D^{-2}q = D^{-3}q = D^{-4}q = 0$ at $x = 0$ and the unknown coefficients of Eq. (2) can be determined. In fact,

$$\begin{aligned} C_0 &= y(0) \\ C_1 &= y'(0) \\ C_2 &= y''(0) = M(0)/EI \\ C_3 &= y'''(0) = Q(0)/EI \end{aligned} \tag{3}$$

as can be seen by evaluating Eq. (2) and its first three derivatives at the point $x = 0$. Here use has been made of the convention that loads and deflections are positive upward. $M(0)$ and $Q(0)$ are, of course, the bending moment and shear force evaluated at $x = 0$.

The solution of Eq. (1) may now be written:

$$y = y(0) + y'(0)x + \frac{1}{EI}\left[M(0)\frac{x^2}{2!} + Q(0)\frac{x^3}{3!} + D^{-4}q\right] \tag{4}$$

A few examples will serve to show the application of Eq. (4).

Example 1. The beam of Figure 1 has for its elastic line the curve:

$$y = 0 + 0 + \frac{1}{EI}\left[-\frac{wL^2}{2}\cdot\frac{x^2}{2} + \frac{wLx^3}{6} - \frac{wx^4}{24}\right] \tag{5}$$

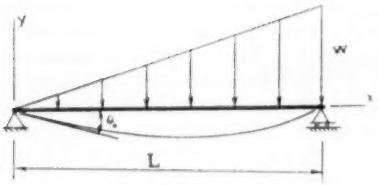

FIG. 2.

Example 2. The beam of Figure 2 has for its elastic line the curve:

$$y = 0 - \theta_0 x + \frac{1}{EI}\left[0 + \frac{wL}{6}\cdot\frac{x^3}{2} - \frac{w}{L}\cdot\frac{x^5}{120}\right] \quad (6)$$

where $-\theta_0$ is the unknown slope at the left end of the beam. This quantity is easily found by equating the deflection to zero at $x = L$.

Example 3. The beam of Figure 3 has for its elastic line the curve:

$$y = 0 + 0 + \frac{1}{EI}\left[M_0\frac{x^2}{2} + Q_0\frac{x^3}{6} - w\frac{x^4}{24} + \frac{w}{L}\cdot\frac{x^5}{120}\right] \quad (7)$$

where M_0 and Q_0 are the unknown moment and shear at the left end. These quantities are easily found by equating the deflection and slope to zero at $x = L$.

When the load function, $q(x)$, is discontinuous, as for instance in the case of a concentrated load, the solution is formally the same. However in this case we have to deal with the integration of discontinuous functions. The conditions of continuity of slope and deflection of the beam are met, since the third and fourth indefinite integrals of the load function are continuous. Figure 4 shows a positive load, P, acting at the point $x = a$, and its first four indefinite integrals. These are:

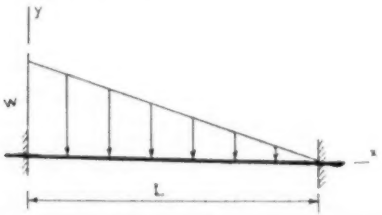

FIG. 3.

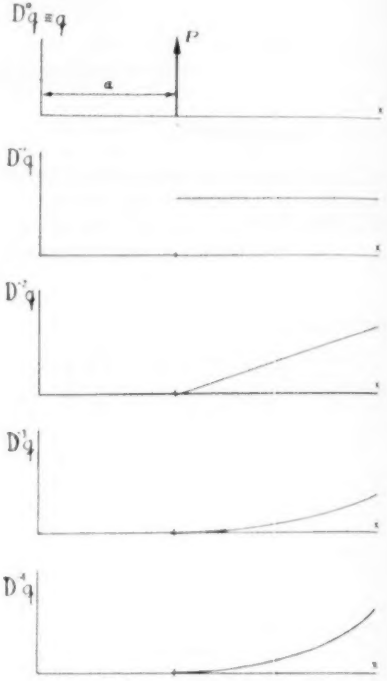

FIG. 4.

D^0q: Concentrated load at $x = a$

$D^{-1}q = D^{-2}q = D^{-3}q = D^{-4}q = 0$ for $x \leqq a$

and for $x > a$: (8)

$$D^{-1}q = P$$
$$D^{-2}q = P(x - a)$$
$$D^{-3}q = P(x - a)^2/2!$$
$$D^{-4}q = P(x - a)^3/3!$$

The reader will easily verify that the corresponding fourth integral for a clockwise moment of magnitude M located at $x = a$ is:

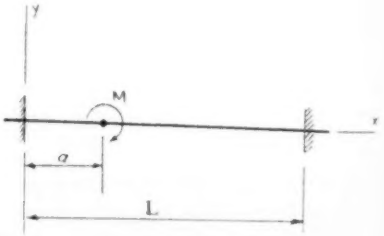

FIG. 5.

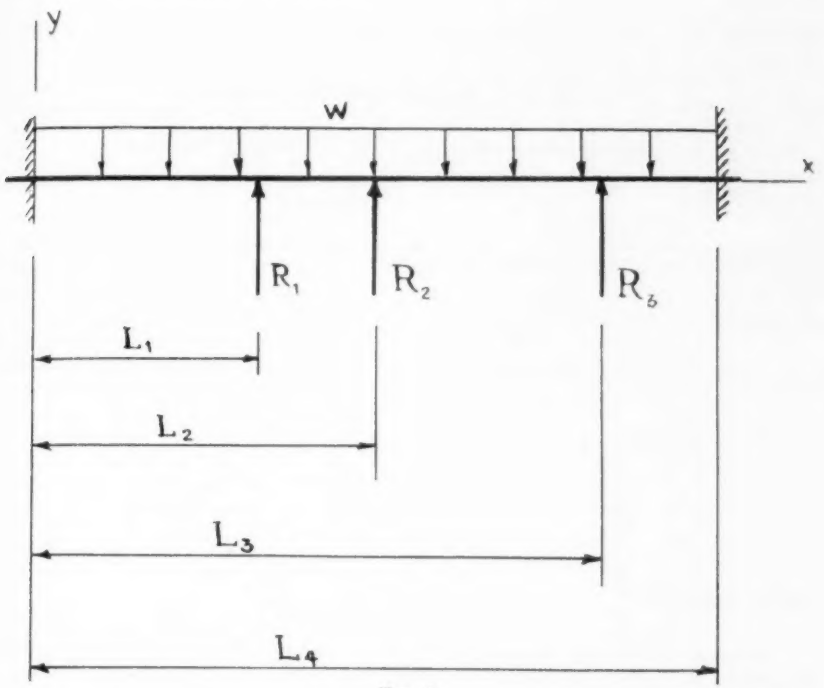

FIG. 6.

$$D^{-4}q = 0 \quad \text{for } x \leqq a;$$

$$D^{-4}q = M(x-a)^2/2! \quad \text{for } x > a. \quad (9)$$

Example 4. The beam of Figure 5 has for its elastic line the curve defined by Eqs. (10) and (11). Where use has been made of Eq. (9):

$$y = \frac{1}{EI}\left[M_0\frac{x^2}{2} + Q_0\frac{x^3}{6}\right]$$

valid $0 < x \leqq a$ (10)

$$y = \frac{1}{EI}\left[M_0\frac{x^2}{2} + Q_0\frac{x^3}{6} + M\frac{(x-a)^2}{2}\right]$$

valid $a < x \leqq L$ (11)

The quantities M_0 and Q_0 represent the unknown moment and shear at the left end of the beam, and are found by the conditions that the slope and deflection are zero at $x = L$ (from Eq. (11)). This problem actually is one which might be expected to be of more than ordinary difficulty for a sophomore if attempted by conventional methods, but the manipulations here do not appear to be unduly confusing or lengthy.

Example 5. Rather highly indeterminate beams can be handled with no conceptual difficulty. The redundant beam of Figure 6 yields the following set of equations:

$$EIy = M_0\frac{x^2}{2} + Q_0\frac{x^3}{6} - \frac{wx^4}{24} \qquad x \leqq L_1$$

$$EIy = M_0\frac{x^2}{2} + Q_0\frac{x^3}{6} - \frac{wx^4}{24} + R_1(x-L_1)^3/6 \qquad L_1 < x \leqq L_2$$

$$EIy = M_0\frac{x^2}{2} + Q_0\frac{x^3}{6} - \frac{wx^4}{24} + R_1(x-L_1)^3/6 + R_2(x-L_2)^3/6 \qquad L_2 < x \leqq L_3$$

$$EIy = M_0\frac{x^2}{2} + Q_0\frac{x^3}{6} - \frac{wx^4}{24} + R_1(x-L_1)^3/6 + R_2(x-L_2)^3/6 + R_3(x-L_3)^3/6 \qquad L_3 < x \leqq L_4 \quad (12)$$

Equations (12) contain five unknowns, M_0, Q_0, R_1, R_2, R_3, which can be solved for by the four conditions of zero displacement at $x = L_1$, L_2, L_3, L_4 and the condition of zero slope at $x = L_4$.

When we have to deal with a beam of non-uniform cross section the equation to be solved is:

$$D^2[EID^2y] = q \qquad (13)$$

The solution can be written down as before:

$$y = y(0) + y'(0)x + M(0)D^{-2}\left(\frac{1}{EI}\right) + Q(0)D^{-2}\left(\frac{x}{EI}\right) + D^{-2}\left(\frac{D^{-2}q}{EI}\right). \qquad (14)$$

Equation (14) is in most cases not as easily handled as Eq. (4), but it can be used in exactly the same manner, and forms a valuable basis for numerical computation procedures.

References

(1) M. Hetenyi, "Deflections of Beam of Varying Cross Section." *Journal of Applied Mechanics*, Vol. 4, No. 2, 1937.

(2) H. D. Conway, *Aircraft Strength of Materials*. Chapman and Hall, London, 1947.

NEW DEANS

Professor Gordon S. Brown became Dean of the School of Engineering at the Massachusetts Institute of Technology on July 1 of this year. He succeeded Dean C. Richard Soderberg.

Dean Brown received the Lamme Award in 1959 and the George Westinghouse Award in 1952. He is particularly noted for his work in the development of education in the electrical engineering sciences. He has been a member of ASEE since 1946.

Dale R. Corson, Professor of Engineering Physics and Chairman of the Cornell Physics Department, has been named Dean of the College of Engineering by the Trustees of Cornell University. Dean Corson succeeded Dean S. C. Hollister on July 1 when the latter retired from the post which he had held for the past 22 years.

He has served as a member of the Special Committee on Space Technology of the National Advisory Committee for Aeronautics, and as a member of the Technical Advisory Panel on Atomic Energy of the Department of Defense. He has also served as a consultant to various other industrial and government electronics and missile activities.

He received the A.B. degree from the College of Emporia in 1934, the M.A. from the University of Kansas in 1935 and the Ph.D. from the University of California in 1938. Prior to World War II he was on the faculty of the University of California and of the University of Missouri.

Dr. Joseph L. McCarthy, Professor of Chemical Engineering at the University of Washington, was appointed dean of the University's Graduate School by the Board of Regents. Professor McCarthy assumed his new post on July 1, 1959. He succeeded Dr. Henry A. Burd, Professor Emeritus in Marketing, who had been acting dean of the University's Graduate School since September, 1955.

Dean McCarthy has been a member of ASEE since 1949.

What's Going On in ASEE?

Annual Report of the Secretary—1958-59

(Abridged, to avoid duplication with reports of other officers, but no items are omitted.)

1. *Finances.* The pro-forma statement indicates that receipts will just about equal the budget total of $117,290 and that disbursements will be about $2,000 more than the budget. It is recommended that, if the audit is in reasonable agreement with the pro forma statement, $5,000 be transferred from the general fund to the reserve for emergencies, any deficiency coming from the reserve for special projects, which amounts to about $4,350. The increased activity in all aspects of the Society's work, and particularly the special projects, make it necessary to include an indirect charge of at least 5% in all contracts and grants. The dues of members should not be used directly or indirectly to aid special projects which are separately financed.

2. *Budget for 1958–59.* The proposed budget of $132,200 is about $15,000 above that for last year. A continued increase in both individual and industrial memberships is expected. Advertising income is increased about 5% because of the major promotional effort now getting underway. The major increase, however, comes from an increase in individual dues of $1.00 per member. The increases in disbursement are primarily to meet cost levels established during the current year, for increases in salaries, and for the employment of a half-time Assistant Secretary. It was not possible to increase the reserve for emergencies from $5,000 to $10,000 and still have a balanced budget.

3. *Individual Membership.* Some comparative statistics for the past few years follow:

Year	55–56	56–57	57–58	58–59
Yearbook, individual members	7,548	7,450	8,057	8,753[1]
New members	639	835	1,040	969
Life members	23	9	18	26
Resignations	297	210	129	219
Deaths	51	45	38	51
Delinquent one year's dues	352	364	362	418
Delinquent two year's dues (to be dropped)	266	181	184	154
Address unknown	73	13	7	24
Individual dues—income	$53,343	$54,127	$57,070	$61,137

The YET membership campaign was effective, but every effort still needs to be made to expand membership. At many institutions, particularly the larger ones, the potential is still great, and it is recommended that the YET's be asked to continue their efforts to promote membership and that the deans of engineering, through ECAC, actively cooperate. It is again recommended that the Executive Committee of each Division critically examine its membership and submit names of outstanding men who should be members to the Secretary so they can be invited to join by a letter from the President and a follow-up from the Division Chairman. This is particularly important for those newer areas of science having an impact on engineering education.

4. *Institutional Membership.* Trends for the past few years are indicated by the following figures, which are the Yearbook totals, except for June 9, 1959:

	Feb. 56	Feb. 57	Feb. 58	Feb. 59	June 59
Active	148	152	152	154	154
Industrial	110[1]	131[1]	132	147	170
Associate	—	—	9	9	14
Affiliate	29	39	41	56	64

[1] Industrial and associate not separated.

The number of industrial members discontinuing membership during the year is 3, as compared to 6 for last year. Five have not paid dues for the current year, whereas only 2 were in that category last year.

5. *Subscriptions.* The number of paid subscribers as of June 10 is 497. This is an increase of 15% over last year. There seems to be a steady growth, and accurate records now are being maintained. The listing of the JOURNAL in the publications of some of the subscription agencies has been continued.

6. *Publications.* High quality papers are being received at an increasing rate. There is a backlog of 230 papers awaiting action, so the immediate problem is one of selection rather than of numbers. Four hundred and fifteen of the 736 papers on hand or received came from sources other than the annual meeting. The advertising income increased about $1,100 or 4.6%, even though the number of pages decreased an average of 1.9 pages per issue, or 10.5%. This apparent contradiction results from all advertising now being at the increased rate initiated last year. A comprehensive campaign to increase advertising is now underway. The ultimate objective is to have advertising income equal the printing costs, but achieving this in less than two or three years is improbable. Having the Editor on a half-time basis is a great improvement and the unsolicited compliments being received about the JOURNAL indicate that the greatly increased time and effort devoted to it are bearing fruit. It also is important to note that an Editorial Committee is being formed to aid the Editor in the selection of papers.

Publications resulting from special studies by the Society during the year were:

1. Engineering Education Exchange Mission to the Soviet Union (25¢)
2. Scientific and Engineering Manpower Requirements for College and University Atomic Energy Activities (25¢)
3. Teaching Tomorrow's Engineers (free)
4. Report on the Indian Institute of Technology at Kanpur (not for sale)

   Annex to the Report on the Indian Institute of Technology at Kanpur

   Reports of Laboratory Consultants for the Indian Institute of Technology at Kanpur, Part I

   Reports of Laboratory Consultants for the Indian Institute of Technology at Kanpur, Part II

In addition, there were the following publications of a miscellaneous nature:

1. Nuclear Energy Education Newsletter, 10 issues (free)
2. A new brochure on Industrial Membership
3. Salaries and Income of Engineering Teachers 1958 (by EJC for EJC and ASEE) (25¢)
4. Trends in Freshman Engineering Enrollment (by EJC for EJC and ASEE)
5. Distribution of 9 news releases, not related to Annual Meeting

It also should be mentioned that the editing of ECRC's biennial Research Review is being transferred to the Editor of the JOURNAL and that work on the 1959 edition is underway.

7. *Office Staff.* The secretary devotes 75% of his time to ASEE during the academic year and full-time during the summer. The Editor is on a half-time basis throughout the year. The six full-time office secretaries and a part-time student girl make the staff the largest it has ever been.

The Secretary also was again relieved of one-quarter teaching to administer the ASEE–AEC Summer Institute program. Thus, actually, the Secretary was full-time with ASEE for the year.

8. *Office Equipment.* Additional furniture and equipment for the new Assistant Secretary will need to be purchased. In addition, the following equipment is needed to economize the time of the staff:

1. A ditto machine for producing ten to fifty copies of a letter.
2. A duplicating machine to avoid retyping to get extra copies of letters received.
3. A new mimeograph machine in order to get better copy.

It is not believed the proposed budget can include the purchase of all this equipment, but it is needed. A local committee to study the transfer of records to an automatic system has not yet been selected.

9. *Secretary's Travel.* During the year the Secretary made 26 trips to attend 34 conferences and meetings. For the first time since becoming Secretary a limited number of speaking and writing invitations were accepted. A number of the meetings attended, other than those directly related to ASEE activities, pertain to the National Defense Education Act for 1958. The lack of close contact with EJC and its Secretaries Committee persists, but the relationship with appropriate Washington offices has improved a little.

10. *Public Relations.* This still is a weak aspect of the Society's operations. Mr. J. I. Mattill is to be congratulated for accomplishing what he does by means of his long-distance operations. His arrangements for press conferences and news releases for the Exchange Mission to the Soviet Union are particularly appreciated. At Berkeley excellent cooperation from the public relations staff was obtained, and Mr. Mattill is to be congratulated and thanked for his ever willingness to beat the drums for ASEE.

Nine news releases, other than those at the Annual Meeting, were distributed during the year, as compared to six for last year. If ASEE is to speak for engineering education, and if ASEE is to be recognized by scientific and Federal organizations as a force to be considered and whose opinions are to be sought, the efforts to inform them of what we are doing and what we think must be increased. It is desirable that thought be given to the employment of a half-time staff member to handle news releases, brochures, etc. Such a person also would be expected to work with national officers in regard to their speeches, do some work with Sections, and be responsible for operating the press room during the Annual Meeting.

11. *Industrial Fellowships.* The fourth Leeds and Northrup industrial fellowship was awarded to Washington University, St. Louis. The Committee made no progress on a brochure, and the same is true of efforts to obtain additional fellowships. Leeds and Northrup is disappointed by ASEE's inactivity, but is encouraged by ASEE's reaffirmation of the program.

12. *YET Paper Contest.* Only 11 papers were submitted in *all* of the Section contests and only 6 in the national contest. In addition, the quality was not considered to be very good by the national judges. It is strongly recommended that the contest be discontinued. It just isn't worth the $500 direct costs and the time and trouble required for distribution of the brochure, etc.

13. *Summer Schools.* Two summer schools materialized. One is sponsored by the Humanistic-Social and English Divisions on "Follow Up to the Report on General Education in Engineering." The other is sponsored by the Engineering Economy Division and is on "Applications of Economic Evaluation in Industry." Both were held in Pittsburgh in conjunction with the Annual Meeting.

14. *Mid-Winter Meetings.* The Relations with Industry, Engineering Graphics and Cooperative Education Divisions held their usual meetings. RWI's College-Industry Conference at the University of Houston on January 30 and 31 was by far the biggest and best ever held. The Engineering Graphics Division met in Detroit on January 21–23, and the Co-op Division in Chicago on January 7–9.

15. *ECAC.* The exchange of information during the year was good. Some reorganization of committees as suggested by ECAC would be in order. There are

many areas in which the Council can work, and its continued activity indicates a desire to do so.

16. *ECRC.* The editing of the biennial Research Review is progressing as a joint effort of the Editor of the JOURNAL and the Secretary of ECRC. Distribution will be by the office of the Secretary. The initiation of a study of Research in the Teaching of Engineers indicates a major shift in interest and the entire Society should support any project which develops.

17. *Projects*

a. *Humanistic-Social Research Follow-up:* G. A. Gullette, Chairman. The project is being brought to a close with the summer school being jointly sponsored by the Humanistic-Social and English Divisions. It is recommended that any funds left in the account after summer school expenses have been paid be transferred to the "reserve for special projects."

b. *Survey of Technical Institute Education:* K. L. Holderman, Chairman. The final report will be published in September, but a brief summary will be available at the Annual Meeting. The McGraw-Hill Book Company will publish the report in book form, and 2,000 copies will be available in paper-back form for distribution by ASEE.

c. *ASEE–AEC Summer Institutes on Nuclear Energy:* Nuclear Committee. The six jointly sponsored summer institutes and the attendance at each are as follows:

Basic Course	
1) North Carolina State and Oak Ridge National Laboratory	30
2) Cornell University and Brookhaven National Laboratory	30
Advanced Courses	
3) Reactor Operation and Design, University of Michigan	19
4) Specialized Nuclear Studies, Argonne National Laboratory	19
5) Chemical Processing, Hanford Works, General Electric Company	8
Technical Institute	
6) Pennsylvania State University and Argonne National Laboratory	22
Total	128

For each institute the applicants were screened by a committee to determine the adequacy of background and appropriateness of taking the course. To administer the program the Secretary was released from his teaching duties one-quarter time for the academic year and the salary increment charged to the project. Plans are developing for additional institutes next summer, and it seems as though programs will be finalized at earlier dates than in the past.

d. *Technical Institute Book:* S. C. Hollister, Acting Chairman. The recommendations of the Committee have not been carried out, the bottle-neck being the Secretary of the Society. About $3,000 remains in the fund.

e. *Development of Engineering Faculties:* H. L. Hazen, Chairman. This committee had another busy year, culminating in the report "Teaching Tomorrow's Engineers," which is designed to encourage students to go into engineering teaching as a career. The booklet is being distributed through the Office of the Secretary at no charge. Professor Harold A. Foecke, Director of the project, has been visiting colleges of engineering having worthy development projects. A brief report to the Society will be made at the Annual Meeting. Support also was given to the publication of EJC of "Salaries and Earnings of Engineering Teachers, 1958." This project is a good example of how a project can indirectly add considerable work to the Office of the Secretary, and it is hoped a 5% indirect cost item can be included in next year's grant from the Ford Foundation, the current sponsor of the project.

f. *Nuclear Energy Education Newsletter:* About 1,400 copies have been sent out monthly throughout the academic year. The text is prepared by Professor V. E. Bergdolt of Purdue University. The Office of the Secretary maintains the mailing list and addresses the envelopes. This now is one item in the contract with AEC for the Summer Institutes.

g. *Educational Mission to India:* W. E. Stirton, Director, N. W. Dougherty, Deputy Director. At the request of the International Cooperation Administration

a team of seven was hurriedly assembled and sent to India for two months to make a feasibility study for the establishment of an institute of technology at Kanpur. A report was submitted to the Government of India before the team left that country, and it was accepted. Consequently an annex report giving specific information on space, staff, facilities, equipment, housing, administration, cost, etc. was prepared. About twenty consultants were used in developing that phase of the work. The contract has been completed, but ASEE most probably will be asked to continue in some advisory capacity if the institution is to be built.

h. *Educational Exchange Mission to the Soviet Union:* F. C. Lindvall, Director. A team of eight engineering educators spent three weeks in the USSR visiting various engineering schools under the sponsorship of the NSF. The final report was published in the May issue of the JOURNAL. Two thousand separate copies will be printed and sold for 25¢ each.

i. *Research on the Teaching of Engineers:* H. W. Barlow, Chairman. The Research Administration Committee of ECRC decided that it was willing to serve as a catalyst to develop programs on research on the teaching of engineers. ECRC and the Executive Board agreed that the study was a worthy one, and the latter allocated $1,500 to the committee for travel expenses to develop programs. The money is to be returned when projects are financed. It is understood that the committee has no desire to conduct projects but merely wishes to serve as a catalyst to get the best qualified group to carry out the studies deemed most desirable. Representatives of other ASEE units interested in the general area are on the committee for the development of programs. Two meetings have been held and a third is scheduled for the Annual Meeting.

j. *Evaluation of Technical Institute Education:* C. C. Tyrell, Chairman. At the request of ECPD, ASEE appointed a committee to make an evaluation of technical institute education, much the same as was made a few years ago for degree programs. The committee will meet for the first time at the Annual Meeting.

18. *Intrasociety Relationships.* Communication between the various units of the Society continues to improve. Most of the units are accepting and responding to their responsibilities in such a way that the Society is functioning as a team rather than as a large number of independent units. Improvement still can be made, but the system of having vice presidents taking responsibility for some units is most helpful.

To the officers of the Society, the members of the General Council, and to all others who have helped make this another successful year for ASEE, the Secretary expresses his most sincere appreciation.

Respectfully submitted,

W. LEIGHTON COLLINS,
Secretary

Report on Western Sections—1958-59

1. *Introduction.* Superior programs and interest in the problems of engineering education contributed to the excellence of the annual meetings of the Western Sections of ASEE during the academic year, 1958–59.

2. *Meetings and Attendance.* The Western Region of ASEE consists of seven Sections. All of these Sections held one regular meeting during the year. In addition, the Pacific Southwest Section held three regional meetings to coincide with the spring meetings of the Northern California, Central California, and Southern California Junior College Association.

The Missouri-Arkansas and Rocky Mountain Sections both scheduled one-day meetings; otherwise the standard pattern was a day-and-a-half meeting. The Pacific Southwest Section meeting was almost two days long, and the North Midwest Section meeting was preceded by the equivalent of a one-day meeting of special interest to the Young Engineering Teachers. Reported attendance at all Section meetings was 891; including wives, the total was 1,048.

Vice President Glenn Murphy attended the North Midwest Section meeting at the University of Wisconsin in Madison. Vice President Ralph A. Morgen attended the Missouri-Arkansas Section meeting at the Missouri School of Mines at Rolla, and President William T. Alexander attended the Southwest Section meeting at New Mexico State University in State College, New Mexico. Because of a conflict with the spring meeting of the Executive Board in Chicago, I could not attend the annual meeting of the Rocky Mountain Section which was held at Utah State University in Logan. I did, however, attend the Kansas-Nebraska Section meeting at the University of Nebraska in Lincoln, the Pacific Southwest Section meeting at Fresno State College in Fresno, California, and the Pacific Northwest Section meeting at Montana State College in Bozeman.

Although the officers of the Rocky Mountain Section expressed regret that the Executive Board meeting in Chicago conflicted with the Rocky Mountain Section meeting, Harold A. Foecke, Director of the ASEE Committee on the Development of Engineering Faculties, addressed the meeting on "Attracting Engineering Teachers"; and Professor Ralph E. Fadum, a member of the ASEE Committee which visited Russia, addressed the meeting on "Engineering Education in the USSR." The appearance of these two men on the program demonstrated a special interest on the part of the Society in the affairs of the Section.

3. *Finance.* Three Sections reported registration fees. Two of these reported a registration fee of two dollars, and one reported a registration fee of one dollar. The Pacific Southwest Section reported annual dues of one dollar. Apparently no other Section now charges section dues. Presumably expenses of the section meetings are financed through local assessments or by the host institution.

4. *Topics.* Each Section planned its program independently of the other Sections. Aside from the business session, and usually a banquet with a speaker who discussed a topic of general interest, there was a wide diversity of program material. Three Sections reported a general theme for the program. These were: "Frontiers of Engineering," "Science in Engineering Education" and "Challenge in Engineering Education." Harold A. Foecke, Project Director of the ASEE Committee on the Development of Engineering Faculties, appeared on the program at the North Midwest Section, the Missouri-Arkansas Section, and the Rocky Mountain Section.

In general, the core of the program was built around technical sessions, round-table discussions, panels, or multi-topic discussions dealing with interesting aspects of engineering education. Because the accreditation of engineering curricula in the State Colleges of California is of immediate interest, it was particularly appropriate that Dr. F. C. Lindvall, past President of the Society and Chairman of the Education Accreditation Committee of ECPD, spoke at a luncheon meeting of the Pacific Southwest Section on "ECPD Accreditation Policies and Procedures." Several Sections scheduled a deans' meeting for discussion of problems of mutual interest.

5. *Young Engineering Teachers.* Generally speaking, YET participation, except in the North Midwest Section, was weak.

Prior to the regular meeting of the North Midwest Section, the equivalent of a day's program of particular interest was scheduled for the Young Engineering Teachers. The theme of this meeting was "The Young Engineering Teacher, His First Five Years of Professional Development." "The Responsibility of the Individual to Develop Himself," "What Industry Can Do to Develop the Young Engineering Teacher" and "What Institutions Can Do to Develop the Young Engineering Teacher" were ably presented at this meeting. These discussions were culminated with an address by Clarence H. Linder, Vice President of the General Electric Company, who spoke on "Some Thoughts for the Young Engineering Teacher During His First Five Years of Professional Development." Seventy-six Young Engineering Teachers were present.

Three Sections reported no activities whatsoever on the part of the Young Engineering Teachers. In other Sections the Young Engineering Teachers were re-

ported to have participated in membership drives.

The North Midwest Section reported four YET Papers; the Pacific Southwest Section, one; and the Pacific Northwest Section, three papers, but only one was submitted in time to be considered in connection with the national competition. Incidentally, the one paper which was submitted from the Pacific Northwest Section won second prize in the national competition. It is my impression that Young Engineering Teachers who might be interested in the YET Paper Contest are more interested in professional development through graduate study and research, because these aspects weigh more heavily than winning a paper contest when promotions are being considered. The YET program was designed for the purpose of encouraging activity on the part of young engineering teachers. I think this program now has doubtful value, and that the younger members of the Society might well be integrated with the older members of the Society at once.

6. *Branches.* Although no specific reports concerning the activities of branches were to be made, it should be noted that in some institutions there are Branches which operate in an informal manner. Undoubtedly, the influence of the Branches has served to stimulate the participation in activities of the Sections and in obtaining new memberships.

7. *Conclusion.* The exchange of program information should be useful in planning future programs. Insofar as practicable, I have attempted to provide an exchange of section programs in the Western Region.

In planning for programs for the coming year, consideration should be given to the development of an interest in the engineering teaching profession, with the Report of the Committee on the Development of Engineering Faculties as a guide, and a continuing interest in the Report of the Follow-up Committee on the Evaluation of Engineering Education.

The officers of the various Sections should continue the drive for industrial memberships and every effort should be made to invite and encourage every eligible junior college to apply for Affiliate Membership in the Society.

Respectfully submitted,

C. L. Eckel,
Vice President, ASEE

Report on Eastern Sections, 1958-1959

1. *Introduction.* Once again, this has been a busy and active year for these sections. The excellent programs, prepared by the Program Committees, attracted non-members as well as members to the meetings in goodly numbers. Proportionately, attendance was much better than last year. It is difficult to make direct comparisons, however, because of the fact that at the time of the writing of this report, the Allegheny Section has not held its annual meeting. Because so many of the members of this section are involved in the annual meeting of ASEE, it is holding its meeting in conjunction with the annual meeting.

2. *Numbers of Meetings and Attendance.* There was no change in the number of Eastern sections, of which there are nine, and there were no significant changes in the number or duration of the section meetings. The Middle Atlantic Section held two one-day meetings. The National Capital Area held four meetings, three of which were evening meetings, and one of which was a morning inspection of the engineering and research laboratories at Fort Belvoir, Virginia. Two of the sections held one-day meetings, three held 1½-day meetings, and one held a two-day meeting.

Omitting the Allegheny Section, 1,750 ASEE members attended the meetings of the eight sections this year, as compared with 1,714 attending the meetings of the nine sections last year. This means that well over one-third of the ASEE members living in the east attended at least one section meeting, and is indicative of the importance of the section meetings as a medium for permitting members to hear excellent papers and to exchange ideas on a variety of subjects, all related to engineering education.

3. *Financing Meetings.* As was reported last year, the method of financing section activities varies from section to section. Most of the sections charge registration fees, which, while ranging from 50 cents to $4.00, are generally $2.00 or $3.00. One section continues to make an assessment of $20.00 against each institution participating in the section's activities. Apparently, inflation has had its effect on section expenses, too, because one section, which apparently did not charge institutional dues during 1957–58, began, during 1958–1959, to charge dues of $10.00 of each institution with 35 members or less, and $15.00 of each institution with more than 35 members. In addition, a registration fee of $3.00 was charged each member attending this section's meeting. In view of the fact that a second Eastern section is resorting to institutional assessments or dues, it seems advisable to remind the sections that an institution which is not a member of ASEE may not become a member of a section. While this action of the Executive Board of ASEE does not preclude a non-member institution from participating in section activities, or even from being assessed for such participation, it is doubtful that such an institution could actually be charged dues unless it were considered to be a member of the section, which would be contrary to ASEE policy.

4. *Topics.* Some of the major areas of interest and discussion at the section meetings were the following:

A. *Engineering Education in Other Countries.* The ASEE Mission to Russia, as well as the keen interest of most educators in learning more about how Russia is endeavoring to educate its engineers and scientists, naturally resulted in this being one of the most popular topics. Four sections devoted part of their program to a report on engineering education in Russia which, in all but one case, was presented by one of the members of the ASEE mission. In addition, one section discussed "The European and His Education" and another considered "Significant Contrasts Between Canadian and U. S. Methods in Engineering Education."

B. *Engineering Education in General.* Quite a few sections gave serious and careful consideration to education in general, and particularly, to engineering education. Titles of the section themes or topics for discussion give an indication of the areas of interest. They were: "The Meaning of True Education," "The Reorientation of Engineering Education," "Frontiers in Engineering Education," "Dilemmas of Engineering Education," "New Developments in Technical and Engineering Education," and "Engineering Education and Leadership."

C. *Research.* This topic did not receive nearly so much consideration at section meetings as it did during 1957–58. According to the programs submitted by the secretaries of the sections, only one section discussed this topic and did so by considering subjects such as "Does Institutional Research Improve Scholarship?" and "Sponsored Research: Aid or Hindrance to Scholarship in Higher Education?"

D. *General.* There were the usual panel discussions or papers in subject matter areas but there appeared to be considerably fewer of these than there were last year. One section set aside a special meeting for the YET's, and another turned part of one of its general meetings over to the YET's to present the program. There was discussion of educational television, the effect of technical institutes on engineering manpower, an evaluation of student performance, the place of laboratories in engineering education, nuclear energy in the engineering curriculum, etc. Certainly, engineering educators do not lack for ideas for programs which will be thought-provoking and of interest to the members of their local sections.

5. *YET Paper Contest.* Participation in the YET Paper Contest was even poorer than during 1957–58. During that year, there was only one section from which no YET papers were received. This year, four Eastern sections submitted no YET papers and the remaining four sections submitted 2, 3, 4 and 6 papers, respectively, for a total of 15, which is indeed a very poor showing.

This lack of interest gives rise once again to the question of whether there is any justification for continuing the YET Paper Contest.

6. *Miscellaneous.* There has been a most encouraging increase in interest on the part of industry in membership in ASEE. Several of the sections made a special effort to invite these industries in their sections which had a special interest in engineering education to send representatives to the section meetings. The Michigan Section devoted one page of its printed program to "Industry's Stake in Engineering Education." Other sections might consider doing likewise next year and sending copies of the program to local industries along with an invitation to have representatives attend the section meetings. It should be noted that one section sent invitations to the junior colleges, which are offering pre-engineering programs, to send representatives to that section's meeting. Mention should be made of two special projects. The New England Section once again published an excellent Bulletin which contained detailed information concerning each of the institutions which are members of that section. In addition, the Allegheny Section in the fall of 1958 issued the Proceedings of its April, 1958, meeting, which contained copies of remarks and papers presented on that occasion.

7. *Conclusion.* One seldom reaches the end of any term of office without being vitally aware of those things which he had hoped to accomplish but which for one reason or another have not been accomplished. I am particularly concerned about the branches of ASEE and how best to stimulate them to serve better the members of ASEE at the local institutions. I hope that my successor will be far more successful than I have been in this respect. In conclusion, I do want to express my appreciation to the officers of the Eastern sections for their cooperation over the past two years. In particular, I want to thank the sections' secretaries for submitting reports to Secretary Collins and me and for sending me extra copies of their section programs so that I might distribute them to the other sections in the East.

It has been a very great privilege and honor to have served ASEE as Vice President for Eastern Sections during the years 1957–58 and 1958–59.

Respectfully submitted,

R. W. Van Houten,
Vice President, East Sections

June 11, 1959.

Report of the Vice-President, General Divisions, June 1959

The General Divisions include Cooperative Education, Educational Methods, Evening Education, Graduate Studies, Relations with Industry and Technical Institutes. In addition, the Ethics Committee and the Committee for Young Engineering Teachers report to the Vice President, General Divisions.

The activities of the individual divisions and committees comprising this group are contained in the reports of their respective chairmen.

So far as general activities are concerned, it may be noted that five of the six divisions and both committees have excellent programs scheduled for the Annual Meeting. The Educational Methods and the Technical Institute Divisions and CYET are to be commended for scheduling conferences on Monday morning to help start the week's activities early. Five individual conferences, four joint conferences, six luncheons, two dinners and a breakfast meeting aside from executive committee meetings and the Wednesday tours attest to the activity of the General Divisions.

Special mention should be made of the intensive and successful cooperation of the RWI Division with the Industrial Membership Committee in obtaining industrial members for the Society.

It should also be noted that the Technical Institute Division is taking a long step forward in planning an objective study of Technical Institute education to follow the recently completed survey of Technical Institute programs.

The vice-president represented the Society at one session of the North Midwest

Section. It is recommended that the incoming vice president be given the opportunity of attending the mid-year meetings of the Divisions coming under his purview.

It must be reported with reluctance that not all divisions have kept the vice-president informed of divisional activities. The lack of information has hampered effective liaison between the divisions and the Executive Board. The splendid cooperation of most of the divisions is acknowledged with thanks.

Supplementary activities included assisting with program arrangements for the General Session on Monday and serving as chairman of a committee to cooperate with ASTM in presenting a symposium on Education in Materials on Monday 22 June 1959 at the ASTM Annual Meeting. Ten speakers are scheduled for the one-day symposium. All ASEE members are welcome to attend and to participate in the discussions.

Respectfully submitted,

GLENN MURPHY,
Vice President, General Divisions

Report of the Vice-President for Instructional Divisions, 1958-59

For several years rather vague expressions of discontent have been spreading throughout ASEE relating to our Divisional organization. Running through the comments is fear that the Society may degenerate into a large number of specialized and disconnected small groups. At the same time there is realization that the varied interests of the individual members are often best served through small groups concentrating on specialized problems.

Apparently, the need of the individual members for specific information is fairly well met by our present Divisional structure. However, there may be a lack of integration.

Perhaps the greatest need in engineering education is for faculty members who are aware of the interrelationships among the various disciplines. There is need for men who recognize the universality of basic principles. If engineers are to be able to solve the increasingly complex problems which are facing mankind, they must be prepared to cross traditional curricular and subject-matter boundaries.

The Policy Committee of the Society was assigned the task of studying the structure of ASEE. Pending a report of this committee, the Instructional Divisions have been attempting to play a more effective role by defining their functions as follows:

(1) to bring major new scientific and engineering developments to the attention of educators,
(2) to show how to add to all segments of the curricula material needed to understand and apply the new developments, and
(3) to show how the present courses already provide the necessary background.

Early in the year it was suggested that perhaps the best way for the Divisions to obtain information on new developments would be to hold meetings concurrently with related subject-matter societies and with new groups such as the American Astronautical Society at regular intervals between annual meetings of ASEE. (Almost all of the instructional and curricular Divisions have related professional groups such as AIEE, ASCE, American Physical Society, American Mathematical Society, etc. Most have interests related to the work of the newer professional societies.) It was suggested that meetings be arranged through the Education Committees of the various societies.

Once an important new development has been identified, its significance for engineering education can be studied by the Division concerned. As soon as the implications for various educational elements have been recognized, the Division can organize a general session for the annual meeting at which time the understanding of all members might be broadened by hearing a comprehensive discussion of the ways in which the new development touches upon all disciplines. It is quite possible that one Division in the

process of studying a new development might hold joint meetings with one or two other Divisions before requesting the sponsorship of a general session. This would serve further to integrate the Society.

Throughout the year the various Divisions have established or continued to maintain liaison with the related professional societies. A joint meeting of representatives from many of the related professional societies together with the chairmen of our Divisions has been scheduled for the 1959 Annual Meeting of ASEE. It is hoped that through this meeting an effective start may be made toward closer coordination of the work of the professional societies and that of ASEE.

During the course of the year requests were received for the establishment of Divisions in Metallurgical and Ceramic Engineering. In order to give the groups recognition and the opportunity to develop sustained interests and programs, the Executive Board of ASEE voted to recommend to the General Council the establishment of a Metallurgical Engineering Committee and a Ceramic Engineering Committee.

Submitted by:

ELMER C. EASTON,
Vice President for Instructional Divisions

June 1959.

Teaching Positions Available

ENGINEERING MECHANICS. ASST. or Assoc. Prof. Teach undegraduate and graduate work and participate in research. Expanding graduate program will provide opportunity to develop new courses. Salary and rank determined by education and experience. Apply: Department of Engineering Mechanics, Box 6204, University, Alabama.

MECHANICAL ENGINEERING teaching positions. Men needed in the fluids-heat transfer-thermodynamics-aerodynamics area, in the theoretical and applied mechanics area, and in nuclear engineering. Large and rapidly growing graduate program through D.S.c. Sponsored research encouraged. No limitations on rank. Salary and rank commensurate with educational background and experience. Apply: C. T. Grace, Mechanical Engineering Department, University of New Mexico, Albuquerque, New Mexico.

ASSISTANT PROFESSOR TO TEACH courses in Applied Mechanics and Dynamics. Master's degree preferred. Department of Mechanical Engineering, Oregon State College, Corvallis, Oregon.

STAFF IN ELECTRICAL ENGINEERing. Attractive positions combining teaching (graduate and undergraduate) and research are available. Appointment at any level from assistant professor up, depending on qualifications. A person with interests in electrical energy conversion and modern electrical machines is especially sought, but openings in other fields are available. Applicants must have Ph.D. or equivalent evidence of research potential. Write Chairman, Division of Engineering, Brown University, Providence 12, R. I.

PHYSICS DEPARTMENT IN PRIvately-endowed engineering college with strong undergraduate and M.S. programs in physics has staff vacancy. Offers opportunity for research and stimulating association with a departmental faculty of 10. Ph.D. required. White T. S. Renzema, Clarkson College of Technology, Potsdam, N. Y.

TWO POSITIONS AVAILABLE IN electrical engineering. Graduate and undergraduate teaching. Write Dean of Engineering, University of Houston, Houston 4, Texas.

CIVIL ENGINEERING-STRUCTURES. Opportunity to head structural division, teaching and directing undergraduate and graduate programs. Attractive possibilities in an expanding graduate and research program. Top salary and rank appropriate to qualifications. Ph.D. preferred. Positions now open. Write to L. M. Laushey, Head, Civil Engineering, University of Cincinnati, Cincinnati 21, Ohio.

THE NEW COLLEGE OF ENGINEERING of The University of Rochester is seeking additional staff in chemical, electrical and mechanical engineering to do teaching and research. Interested applicants should write to the appropriate department at The University of Rochester, River Campus Station, Rochester 20, New York.

OPPORTUNITIES AT ROBERT COLLEGE, Istanbul, Turkey, for qualified men in engineering mathematics, physics, and chemistry interested in combining teaching and development of limited research and consulting with opportunity to live and travel in vital part of world: Strengthening staff, modernizing undergraduate engineering curricula, beginning graduate programs in engineering, developing undergraduate and later graduate programs in sciences, constructing new science and engineering building to prepare engineers for industrial and technological development of Turkey and Middle East. Challenging job with far-reaching possibilities. Address inquiries to Dean Howard P. Hall, College of Engineering, Robert College, Bebek Post Box 8, Istanbul, Turkey; copy to Near East College Association, 40 Worth Street, Room 521, New York 13, N. Y.

TEACHING POSITION IN E.E. Teach machinery courses, some graduate classes at night. Must have M.S. or Ph.D. degree. Appointment in February. Contact head Electrical Eng. Dept., University of Akron, Akron 4, Ohio.

POSITIONS AVAILABLE FOR teaching mechanics of solids and fluids on undergraduate and graduate levels. Qualifications for and interest in research are also desired. Salaries and academic rank will be commensurate with education and experience. Write R. W. Moorman, Head, Department of Engineering Mechanics, Clemson College, Clemson, S. C.

MECHANICAL ENGINEERING DEpartment has opening for a man to teach and direct work in machine tools and manufacturing processes. Desire man with interest in research on basic cutting and forming phenomena, and having M.S. or Ph.D. Well equipped laboratory, midwestern location. Write to 50-3, JOURNAL OF ENGINEERING EDUCATION, University of Illinois, Urbana, Illinois.

FACULTY POSITIONS AVAILABLE. Faculty positions in Departments of Aeronautical, Mechanical, Electrical Engineering and Applied Mechanics. Subject fields of aerodynamics, thermodynamics, nuclear power, heat transfer, and engineering materials. Desire individuals with doctoral degrees to develop strong offerings in undergraduate and graduate courses, plus initiation of research of own choosing. Salaries open, consulting opportunities available. For further information write 50-2, JOURNAL OF ENGINEERING EDUCATION, University of Illinois, Urbana, Illinois.

ENGINEERING ADMINISTRATION Program, School of Engineering has positions open beginning February and/or September 1960, for Associate and Assistant Professors of Engineering Administration; Masters degree required, preferably Ph.D.; Salary open. Send qualification record to Professor J. E. Walters, School of Engineering, The George Washington University, Washington 6, D. C.

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